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ARCHITECTURAL CONSERVATION TECHNOLOGY

VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA

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NOTE: Since this manual was in production when federal goverment departments were restructured in 1993, it was impossible to update all in-text government references. The Canadian Parks Services (CPS) of Environment Canada is now Parks Canada of the Department of Canadian Heritage, and Public Works is now part of the Department of Government Services.

Included within the seven volumes of the ACT manual is both basic and specialized information on architecture, engineering and landscape works.

References at all levels within these disciplines, useful both in practice and in training, are intended to:

- introduce and familiarize the user with conservation concerns;
- serve as an "aide-mémoire" at both the design and managerial levels; and
- provide guidance to professional consultants responsible for recording and analysing historic structures, and applying recommended conservation methods to their protection and preservation.

All procedures outlined in these publications should be read in conjunction with the reference material, manufacturer's literature and the relevant Canadian Parks Service – National Historic Sites Management Directives.

In all matters where detailed specifications are required, such as building codes, fire regulations and the use of chemicals, the prevailing and local references and regulations must be consulted and applied.

Please note that the ACT manual has been prepared within the context of Parks Canada Policy (1979). The newly proposed Canadian Parks Service Policy (1990) establishes additional and broader directions that, however, do not alter the orientation of the technical material covered. The ACT manual reflects the well established principles of conservation as defined by national and international charters and conventions – see Vol. I Appendix.

Within the proposed policy, the Cultural Resource Management (CRM) section (see Vol. I, Appendix 5.17) establishes the overall framework for the conservation and presentation of the cultural assets administered by CPS, on all CPS properties, including those in National Historic Sites, Historic Canals, National Parks, National Marine Parks, and other CPS properties. In the event of a conflict between the direction provided by the ACT manual and that provided by CRM Policy, the latter applies.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

1
LEVELS OF INTERVENTION

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ORIGINAL DRAFT: JULIAN SMITH

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1.0 INTRODUCTION

Many different design strategies have been used by architects, engineers and physical planners in conserving and adapting historic properties. In most cases the chosen category of intervention represents a compromise between the demands of protection, ongoing use and budgetary constraints. This process of compromise makes it useful to have a framework within which alternative approaches can be considered, evaluated and discussed.

This article provides the basis for such a framework by identifying and classifying the major levels of physical intervention applicable to historic properties.

1.1 CONTEXT FOR INTERVENTION

The design process for developing historic sites must define the best methods for adapting existing heritage resources to satisfy program objectives. Simple reformulation of the site's operating and maintenance capabilities may be sufficient or, as in most cases, significant physical changes will be required.

The management of the physical changes that occur on historic sites over time is the most important aspect of conservation. Therefore, the design process must be evaluated as much in terms of the intervention strategy itself as in terms of the visible product that emerges.

2.0 CATEGORIES OF INTERVENTION

2.1 ESTABLISHING A FRAMEWORK

Initial distinction can be made between temporary protective measures, usually done as part of predevelopment maintenance and measures identified as part of a more extended site development program.

Temporary protection techniques are designed not to limit long-term development options and to be fully reversible. Long-term development techniques, on the other hand, are implemented only after a thorough understanding of the property has been gained through research and site investigation, analysis and recording and are often irreversible.

The modification and replacement categories imply significant changes on site. They can be further subdivided on the basis of those changes which attempt to recover earlier period forms

Categories of Intervention

and detailing (turning back the clock) and those which move towards essentially contemporary design solutions.

a. Short-term protective measures: Interim protection
b. Long-term development alternatives:
    - Preservation "as is" – **Stabilization**;
    - Modification:
        - to contemporary forms and detailing – **Rehabilitation**
        - to period forms and detailing – **Period Restoration**
    - Replacement:
        - to contemporary forms and detailing – **Redevelopment**
        - to period forms and detailing – **Reconstruction**

The terms above provide the headings used below in the discussions of technical design and cost issues associated with each level of intervention.

2.2 SCALE OF APPLICATION

For any type of intervention, the scale of application can vary considerably. Design decisions may relate to entire historic districts, sites, structures or individual building components. A given project may combine several categories of intervention at different scales. Major development schemes are usually characterized by a general overall approach within which local decisions are made.

3.0 INTERIM PROTECTION

3.1 GENERAL REMARKS

Interim protection involves the application of techniques designed to provide temporary consolidation while awaiting long-term preservation or adaptation. These techniques include:

a. interim structural stabilization;
b interim environmental control programs, including temporary weatherproofing, insect and fungal eradication and mothballing;
c. interim safety and security measures; and
d. interim landscape control.

The implementation of preventive maintenance routines is not dealt with here since it does not normally involve design intervention.

3.2 CHARACTERISTICS

a. The primary emphasis is on protection, that is, maintenance of all existing fabric in its as-found form.
b. The design is neutral. Progressive deterioration is controlled, but no attempt is made to hide, remove or correct other evidence of decay if a situation has stabilized.
c. The effects are reversible. Techniques used will allow the site or structure to be stabilized later and developed in this preserved state or modified by rehabilitation or period restoration, in order not to limit long-term development options.
d. The activity is dependent on co-ordinated maintenance programming. Monitoring and inspection routines are used to compensate for limited scope in the investigation and design intervention phases.

3.3 DESIGN CONSIDERATIONS

Short-term conservation techniques are critical to the overall design development of historic sites. If implemented immediately after acquisition, they ensure the fullest availability of usable information during later phases of the conservation process (see Vol. I.2) and allow the widest variety of long-term design options. They prevent the irreversible deterioration or loss of the physical record of the site's evolution.

These short-term techniques can play an important role in conjunction with long-term maintenance programs before, during or after full site development. By providing a holding action while more permanent solutions are developed and designed, they prevent a gradual loss of structural or architectural integrity and historical authenticity.

3.4 COST CONSIDERATIONS

Short-term conservation techniques often require financial expenditures which, even when substantial at the point of implementation, are fully recoverable over time. These expenditures concentrate on areas of progressive deterioration. They save future expenditures on such items as more complex structural work, more extensive replacement and restoration of historic elements, more indirect and time-consuming research procedures due to loss of fabric and more complex long-term maintenance programs.

Interim Protection

To allow effective implementation of short-term techniques, significant funding often has to be allocated to a project before a full research or site development program is underway.

3.5 REFERENCES

For more extensive technical information, see Section 3, "Interim Protection."

4.0 STABILIZATION

4.1 GENERAL REMARKS

Stabilization (or preservation) involves the application of techniques designed to preserve and consolidate existing historic fabric for an extended period. It may take place selectively as part of a major development program. Techniques include the use of chemical preservatives, cleaning agents and coatings; the upgrading of environmental controls; internal and external structural bracing and reinforcement; and limited replacement and splicing of badly deteriorated areas. Dismantling and reassembly can also be included, to the extent that the historic material is treated and reused in its original context.

Stabilization

4.2 CHARACTERISTICS

a. The primary emphasis is on protection, that is, maintenance of historic resources with their existing form, integrity and materials, without significant adaptation or restoration.
b. The design is neutral. There is little attempt to correct static structural deformations or architectural additions and anachronisms, except where such actions would be required for protection purposes.
c. The effects are sometimes not reversible. Unlike interim protection, techniques are used which may irreversibly alter various chemical and physical properties and structural design features in the interest of long-term protection.
d. The activity is dependent on co-ordinated maintenance programming. Good preventive maintenance routines are the most effective and least damaging means of continuing protection.

4.3 DESIGN CONSIDERATIONS

The preservation and consolidation approach puts significant constraints on the development of design alternatives, since the as-found form of the property or component becomes a major controlling factor as to how it can be used. Considerable imagination and subtlety are needed in the development of the project implementation scheme and functional program. The resulting environment represents the richest possible alternative in terms of historic authenticity and integrity and the potential for additional research.

4.4 COST CONSIDERATIONS

Costs for stabilization vary considerably. The important independent variable is the condition of the existing site resources. The priority on keeping fabric in place can create a need for costly and complex field operations and high-quality site supervision. Capital costs can be kept down by co-ordinating the intervention with effective continuing maintenance programs. For sites and structures in moderate-to-good physical condition, stabilization costs (implementation phase) will vary considerably, but should average about one-quarter to one-half the cost of equivalent new construction. The exception is complete dismantling and reassembly, which approximates or exceeds the full cost of new construction.

Predesign costs include a moderate requirement for historical, archaeological and architectural research, while more detailed investigations can be limited to the analysis of the physical conditions on site.

4.5 REFERENCES

For more extensive technical information, see Section 4 "Stabilization."

5.0 REHABILITATION

5.1 GENERAL REMARKS

Rehabilitation and adaptive reuse (the first type of modification) involve the application of techniques designed to satisfy various contemporary requirements while preserving the integrity of surviving historic fabric. These techniques may include structural and mechanical modifications where building services are upgraded and new levels of fire safety, structural integrity and environmental controls are provided. They may also include architectural modifications of plan and finish to satisfy the functional and operational requirements of the property or to provide new facilities or services.

5.2 CHARACTERISTICS

a. A compromise is reached between protection and adaptation. The design solutions implemented safeguard the important aspects of historic resources while adequately meeting current program requirements. This process assumes a clear definition of the extent, quality and condition of the resources, an explicit description of the categories of intended use and considerable architectural design sensitivity.
b. The design is flexible. There is continual interaction between contemporary design intentions and the constraints of existing historic resources (form, layout, fenestration and the like).
c. The effects are partially reversible. In most cases there is considerable alteration and destruction of as-found materials and structural systems to satisfy contemporary requirements. Some reversibility is possible in changes to spatial arrangements and functional operation if new material is added with allowance for future removal.
d. There is a requirement for follow-up maintenance. Well-defined inspection routines are necessary to

permit detection of new and unsuspected change and decay set in motion by altered structural and environmental conditions.

5.3 DESIGN CONSIDERATIONS

Appropriate rehabilitation takes advantage of how a site or structure has evolved and is able to continue the process in a sympathetic way. Adaptation is usually least damaging when a traditional function is maintained. The most significant physical characteristics likely to be affected are:

a. spatial organization and layout;
b. materials, finishes and decorative elements;
c. structural design and detailing; and
d. mechanical and operating systems.

These four characteristics constitute a physical record of past activity and intent and the modification of one aspect usually affects the other three. The relative merits of each have to be properly assessed and interrelated before appropriate modifications of any kind can be designed.

5.4 COST CONSIDERATIONS

The most critical cost variables in rehabilitation are the extent of existing physical resources (for example, is the site mostly intact or is it missing major components?) and structural condition. Assuming that only sites or structures in relatively good condition are designated for adaptive reuse of this kind, rehabilitation costs (implementation phase) average about fifty to seventy-five percent of the cost of equivalent new construction. Individual projects vary, depending on site characteristics.

In addition to a need for thorough structural investigation predesign costs include a requirement for some architectural and historical research (plus archaeological excavation) to provide guidance during the design process.

5.5 REFERENCES

For more extensive technical information, see Section 5 "Rehabilitation."

Rehabilitation

6.0 PERIOD RESTORATION

6.1 GENERAL REMARKS

Period restoration (the second type of modification) involves the application of techniques designed to recover the form and detailing of an earlier period in the property's evolution. Techniques include the removal of later additions, the stabilization of surviving period fabric and the replacement of missing original elements. Complete restoration applies these procedures to all aspects of the site or structure, including the architectural layouts, finishes and decorative features; the structural forms and detailing; and the mechanical and operating systems. It duplicates both the appearance and the behaviour of the original, through accurate reuse of period construction and assembly techniques in the repair and replacement work. Partial restoration, more limited in scope, concentrates on the architectural or visual aspects of the heritage resource. It introduces substitute materials, technologies and support systems to achieve a desired effect without the research and implementation costs associated with a strict adherence to period technology.

Full or partial restoration can result in the loss of significant historic fabric and design elements from later or earlier periods in the property's evolution, thereby diminishing its historic place in the passage of time. International conservation practice and Canadian Parks Service (CPS) policy discourage restoration for these reasons unless the structure is in good condition and retains much of its historic integrity. Prior to implementing a period restoration, the heritage significance of alterations to the property should be assessed.

6.2 CHARACTERISTICS

a. A compromise is reached between protection and adaptation. Design solutions are implemented which protect only those resources dating from certain periods.
b. The design is rigid. A predetermined design solution exists which is flexible only to the extent that new information arises during design and construction.
c. The effects are largely irreversible. The process involves considerable alteration and destruction of non-conforming materials and spatial arrangements.

Period Restoration

d. There is a requirement for follow-up maintenance. Well-defined inspection routines are necessary to permit detection of new and unsuspected processes of change and decay set in motion by altered structural and environmental conditions. Additional demands are placed on maintenance if faulty original design details are reproduced.

6.3 DESIGN CONSIDERATIONS

The design process in a complete period restoration project is defined by external criteria provided by historical and physical evidence. It does not have the flexibility of rehabilitation work. The design solution requires complete familiarity with the resource material and the physical conditions on site. It requires the ability to synthesize the evidence into a unified physical design scheme and to translate that scheme into working drawings and specifications.

In partial restoration, variables arise with the introduction of substitute design concepts and techniques. Deviation from historical precedent is often justified on the basis of eliminating unwanted behavioural characteristics of the original. These changes, however, can eventually produce serious deterioration problems because of incompatible life cycle characteristics between the new and the old. The overall approach is inappropriate if the structural or mechanical aspects of the original are significant.

6.4 COST CONSIDERATIONS

The important cost variable in period restoration is the amount of usable period fabric surviving on site. The number of additions and visual alterations is relatively insignificant if original material is still in situ. For a site with most period resources intact, partial restoration might cost as much as new construction. Complete period restoration may be double or triple the equivalent of new construction costs. Individual projects will vary significantly because of authenticity of methods and site characteristics.

Predesign costs for restoration activity are also very high because of the need for detailed on-site investigations and extensive supporting historical and architectural research.

6.5 REFERENCES

For more extensive technical information, see Section 6 "Restoration."

7.0 REDEVELOPMENT

7.1 GENERAL REMARKS

Redevelopment involves the construction of compatible contemporary facilities to replace missing element or to increase density in a historic environment.

These facilities may have historical antecedents on the property or in the area which can be reinterpreted in contemporary form or which may represent totally new elements.

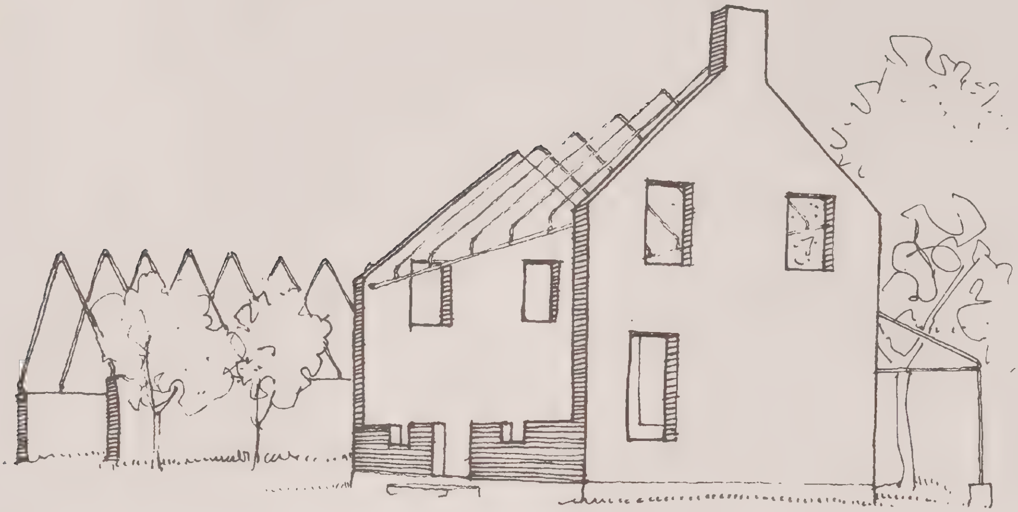
In the case of historic sites established for commemorative purposes, it is occasionally the practice to accurately reconstruct missing or poorly preserved historic structures to enhance the presentation program. Reconstruction is problematic; the more exact and faithful it is to the original, the more liable it is to confuse or be misunderstood; such structures can assume dominant roles on a site and can divert maintenance resources away from authentic historic structures. The CPS policy on Cultural Resource Management (CRM) now discourages the design of new buildings as reconstructions except in the most exceptional circumstances.

7.2 CHARACTERISTICS

a. There is no direct emphasis on protection. Procedures are used which are basically unrelated to the preservation of historic fabric, except where a new facility may create a better setting for genuine historic elements or provide an alternative location for potentially damaging functions.
b. The design is flexible. There is continual interaction between contemporary design intentions and the constraints of existing historic resources.
c. The effects are partially reversible. In the replacement of an existing structure, there could be direct loss of physical fabric. In the case of new construction in open areas, some reversal is possible if allowances are made for future removal.
d. There is a requirement for follow-up maintenance. These demands are similar to those for any contemporary development.

7.3 DESIGN CONSIDERATIONS

Redevelopment and infill on a historic site affects both the



Redevelopment

physical and functional aspects of the historic environment and is therefore subject to the same need for control and review as development within a historic structure. Characteristics of height, proportion, profile, materials and siting are all significant and, in area conservation schemes, may be subject to guidelines and restrictions. Design solutions have to be sympathetic to historic precedents while avoiding confusing or misleading treatments.

The impact of redevelopment on existing historic resources, the site itself or archaeological remains, has to be taken into consideration.

7.4 COST CONSIDERATIONS

While the constraints of the historic environment may prevent the most efficient and economical use of a site, the actual construction costs for redevelopment approximate those for any similar new construction.

Predesign costs include the need for background historical research and for careful design analysis of the site and its existing physical assets.

8.0 EVALUATION

The selection of a design strategy for a specific site is based on both practical and theoretical considerations. Practical considerations are specific to the property and concern the realistic technical alternatives within any one level of intervention given the conditions that exist on the property. Theoretical issues are more general and stem in part from the competing (and sometimes conflicting) demands of protection and commemoration.

In terms of historic resource protection, the less severe forms of intervention (that is, interim protection, stabilization, rehabilitation and minor restoration) are recognized in the Parks Canada Policy (1979) and in other national and international agencies in the conservation field as preferable courses of action. These categories emphasize the preservation of existing on-site resources, which carry within themselves the irreplaceable and complex physical record of the site's history. They recognize that if that record is destroyed or significantly altered, the continuity of the information is lost and the potential for future public understanding and appreciation is greatly affected.

The development and presentation of historic sites is intended to enhance the public's understanding and enjoyment of an overall cultural heritage. The physical resources on site are a means to this end as well as an end in themselves. For this reason, the more severe levels of intervention (full restoration, demolition and development of new facilities) are occasionally justified. Documentation should precede and follow all modification to historic properties.

The technical and procedural implications of these issues for the design process are identified and discussed in Section 2 "Design Criteria."

Drawings by Julian Smith.

VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

2
DESIGN CRITERIA

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CONTENTS

1.0 INTRODUCTION

This publication provides a procedure for evaluation of design options for the development of historic properties and sites. For any given heritage property a number of development options will exist. The decision as to which option to pursue must be based on the specific technical issues presented by the property, operational and functional requirements and, at a more general level, the issues arising from the principles and practices of cultural resource management. The following framework will assist professional and technical staff in this process of evaluation and selection of a design approach.

Palace Grand, Dawson, YT

2.0 DESIGN ALTERNATIVES

2.1 CATEGORIES OF INTERVENTION

The major categories of physical intervention applicable to historic site development are identified and discussed in Section 1. The following is a summary of that framework:

a. Short-term protective measures:
   - Interim protection;

b. Long-term development alternatives:
   - Preservation "as is" – **Stabilization**
   - Modification:
     - to contemporary forms and detailing – **Rehabilitation**
     - to period forms and detailing – **Period Restoration**
   - Replacement:
     - to contemporary forms and detailing – **Redevelopment**

There is also the possibility of non-intervention. This would involve setting up a full maintenance program but not otherwise altering the site in any way. Details of maintenance programming are provided in Vol.V.

2.2 SCALE OF APPLICATION

For any type of intervention, the scale of application can vary widely. Design decisions may relate to anything from entire historic districts to individual building components. A given site development project may combine several categories of intervention at different scales. Major development schemes are usually characterized, however, by a general overall approach within which local decisions are made.

The design evaluation process on a given site should first examine the large-scale design approach and use this as a context for further evaluation of smaller scale design decisions.

3.0 PRIORITIES

3.1 CANADIAN PARKS SERVICE POLICY

The CPS interim policy on Cultural Resource Management (CRM) provides a basic framework and criteria for decisions regarding design for development of sites or structures of national historic significance.

Fortifications, Quebec City, PQ

The overall program objective is "to protect and present commemorated resources of national historic significance… for the benefit, education and enjoyment of this and future generations, in a manner that respects the significance and irreplaceable legacy represented by those resources."

Both aspects of this objective put the management of historic sites in the context of security against deterioration and, particularly, design development with minimal alteration to the historic resources themselves. It emphasizes consideration of the protection of these resources as an end in itself rather than as a means to an end for "… without protection there can be no historic site… and without presentation there can be no understanding of why the site is important to our history…" (NHS Policy, Protecting and Presenting).

The Canadian Parks Service makes protection of historic resources a primary consideration (CRM 3.4.1.1).

More detailed direction is given under part 1.0 Principles of Cultural Resource Management, part 2.0 The Practice of Cultural Resource Management and part 3.0 Activities of Cultural Resource Management. More detailed policy direction is given under 3.4 Conservation. It describes, in the general language of minimal intervention, approaches to historic sites development:

a. respect for existing form and material;
b. impact of the (design) on the integrity of historic fabric; and
c. (development) involving replacement are most interventionist and will be considered last.

It also identifies categories of intervention. They are:

a. Preservation: Consolidation and maintenance of existing form, material and integrity, retard deterioration and prevent damage. These activities involve the least possible intervention;
b. Modification: A higher level of intervention, it involves change of the existing form or materials through repair, replacement or addition to fabric or building components. Modifications may be made to accommodate new uses or requirements. It includes:
   - Restoration – the accurate recovery of an earlier form, fabric and design. Depending on the degree of intervention required, restoration may be a protection or presentation activity;
   - Rehabilitation – the modification of a property to adapt it to new or changed uses or to meet various functional requirements while preserving the heritage character of the structure.

Historic Properties, Halifax, NS

3.2 FEDERAL HERITAGE BUILDINGS POLICY

Chapter Nine of the Treasury Board Manual on Real Property Management outlines the federal government's real property management goals with respect to heritage buildings conservation. The overall objective of the FHB Policy is to "protect the heritage character of Crown-owned buildings."

Through its requirement to consult the FHB Committee and obtain appropriate advice and its consideration of development of historic properties in the context of sustainable development, the FHB Policy puts an emphasis on consideration of the **impact** of development on heritage features.

More detailed direction is given in the Federal Heritage Buildings Review Office's (FHBRO) criteria for review of intervention which require that the level of intervention be identified and where the goal of minimal alteration of historic fabric and design features is spelled out. These criteria also require analysis of the implications of meeting operational and functional requirements, particularly those arising from a change in use.

3.3 INTERNATIONAL CONVENTIONS

The impulse to commemorate significant aspects of the past is one that Canadians share with others around the world. Most nations have formal or informal programs of this nature, and over 100 countries, including Canada, adhere to the United Nation's World Heritage Convention. The Convention has as its objectives the identification, protection, conservation and presentation of cultural and natural heritage places of outstanding universal value. CPS also participates in the work of the

International Council for Monuments and Sites (ICOMOS) and the International Centre for the Study of Preservation and Restoration of Cultural Property (The Rome Centre).

The major document formulated by ICOMOS relating to design intervention on historic sites is the Venice Charter of 1964. (See Vol. I, Appendix 5.1).

The Venice Charter touches on some aspects of design intervention not dealt with specifically in the Parks Canada Policy. Under the term "Conservation" Article 5, new development as defined above states that "the conservation of monuments is always facilitated by making use of them for some socially useful purpose" and accepts the possibility of changes in function. It then goes on to restrict rehabilitation or adaptive reuse design to those modifications which do not change the layout or decoration of the original. New construction, demolitions or modifications should not alter existing relations of mass and colour.

Restoration is treated separately from conservation and qualified by the following comments:

> The process of restoration is a highly specialized operation. Its aim is to preserve and reveal the aesthetic and historic value of the monument and is based on respect for original material and authentic documents. It must stop at the point where conjecture begins... (Article 9).
>
> The valid contributions of all periods to the building of a monument must be respected, since unity of style is not the aim of a restoration. When a building includes the superimposed work of different periods, the revealing of the underlying state can only be justified in exceptional circumstances and when what is removed is of little interest and the material which is brought to light is of great historical, archaeological or aesthetic value, and its state of preservation good enough to justify the action (Article 11).

Other UNESCO conventions make indirect reference to intervention. For example, from the Recommendation Concerning the Protection, at National Level, of the Cultural and Natural Heritage (UNESCO, 1972) [See Vol. I, Appendix 5.5]:

> Any work done on the cultural heritage should aim at preserving its traditional appearance, and protecting it from any new construction or remodelling which might impair the relations of mass or colour between it and its surroundings (Article 23).
>
> A plan should be prepared for protection, conservation, presentation and rehabilitation of groups of buildings of historic and artistic interest. It should include peripheral protection belts, lay down the conditions for land use and specify the buildings to be preserved and the conditions for their preservation.... Any work that might result in changing the existing state of the buildings in a protected area should be subject to prior authorization.... Internal alterations to groups of buildings and the installation of modern conveniences should be allowed if they are needed for the well-being of their occupants and provided they do not drastically alter the real characteristic features of ancient dwellings (Articles 33-36).

And from the Recommendation Concerning the Preservation of Cultural Property Endangered by Public or Private Works (UNESCO, 1968):

> Historic quarters in urban or rural centres and groups of traditional structures should be zoned and appropriate regulations adopted to preserve their setting and character, such as the imposition of controls on the degree to which historically or artistically important structures can be renovated and the type and design of new structures which can be introduced.... Due allowance should be made for the modification of ordinary regulations applicable to new construction; these should be placed in abeyance when new structures are introduced into an historical zone (Article 24).

4.0 APPLICATION

The following subsections define a process for determining the design approach to be used on a specific property. It involves, first, identifying the physical condition and historical integrity of surviving historic resources, and then priorizing a list of feasible design alternatives and, second, reviewing the functional requirements for the site and determining their flexibility. Each successive design alternative is then assessed in terms of its potential for satisfying the functional requirements until an acceptable match is made. Such a match must be kept as high on the priority list as possible.

4.1 ASSESSMENT OF EXISTING RESOURCES

Any property which becomes a national historic site or federal heritage building must contain, by definition, historically significant historic resources. These resources give it its importance and must be the starting point for any proposed design activity.

Sufficient information should be gathered to allow both a historical and physical perspective on the property to be established.

a. Historical perspective:
For purposes of design evaluation, the historical perspective should be based on an understanding of the site's evolution, and the extent of the material that survives intact from each major phase. Where changes have occurred it is important to establish whether the earlier elements were preserved intact behind new materials and finishes, were modified and rearranged or were simply destroyed. It is also important to assess whether the changes reinforced earlier patterns of spatial organization and use, or obscured and obliterated them. Historical research also provides a basis for assigning value to a resource and its various components. A well-documented structural history should form the basis for establishing the historical perspective.

b. Physical perspective:
Again in the context of design evaluation, the physical perspective should involve an understanding of present physical conditions, including the types and causes of deterioration, and the capability of existing resources to withstand the various environmental forces at work on the site. The physical perspective should be based on detailed on-site surveys and material analysis.

4.2 PRIORITY LIST OF APPLICABLE DESIGN ALTERNATIVES

Based on the assessment of existing resources, a number of possible design alternatives should be identified within the general framework outlined in 2.0 above.

Each alternative should be described in sufficient detail to allow an understanding of its projected impact both on the overall site and on individual structural and landscape elements. Class D estimates should also be provided.

This list should then be prioritized in terms of the policy directions outlined in 3.0 above. This will involve a technical assessment of each alternative and a judgement as to its relative impact on the site. In general, however, this sequence will be as follows:

4.2.1 *Highest priority*

a. Preventive maintenance program – assumes existing resources are stable;

b. Preservation – assumes existing resources are reasonably intact but unstable or vulnerable;

c. Modification –
• rehabilitation assumes rehabilitation is possible without significantly changing layout or decoration;
• restoration – assumes existing resources are in good condition, reasonably intact, and provide sufficient data for accurate reconstruction of missing parts; or

d. Replacement – assumes dispensable structural units or open landscape areas and sufficient design controls to ensure compatibility.

4.2.2 *Lowest priority*

As can be seen, preservation is preferable to modification, and modification is preferable to replacement.

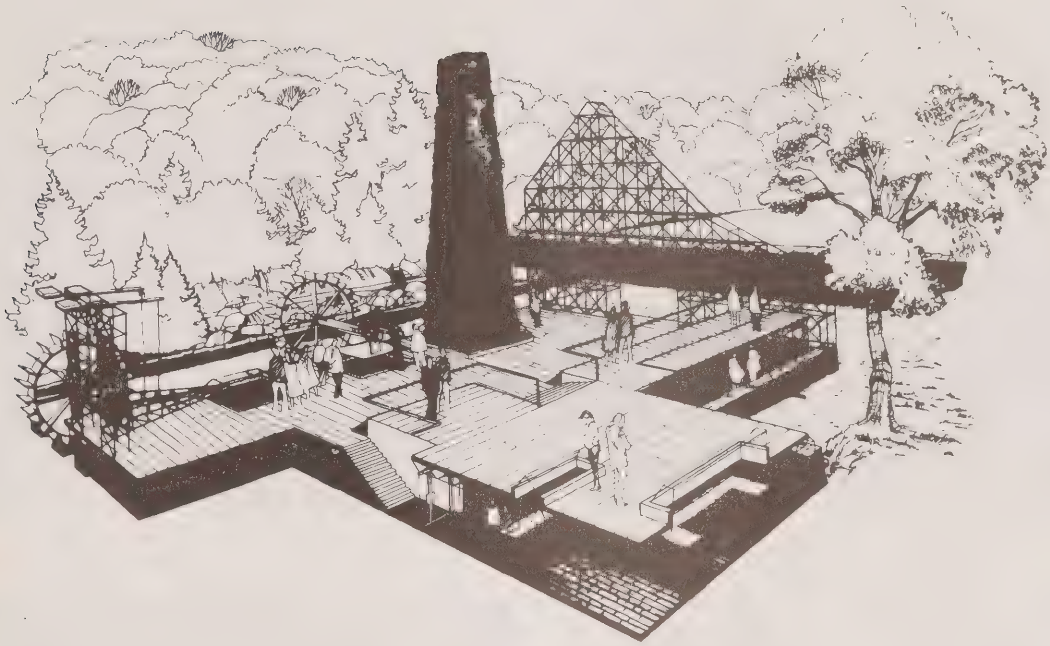
4.3 DEFINITION OF PROGRAM REQUIREMENTS

As a separate activity, program requirements for the site should be established. These will follow from expectations in terms of eventual site interpretation and use. Estimates should be made of functional requirements in terms of some or all of the following:

- visitor service facility requirements
- public access considerations
- interpretive display and communication requirements
- public safety requirements
- possibilities for full or partial continued use
- possibilities for full or partial adaptive use

4.4 FUNCTIONAL ASSESSMENT

Once these functional requirements have been identified and expressed, each design alternative can then be examined in turn as it relates to the fulfillment of program needs.



Site interpretation: Les forges du Saint-Maurice

This examination should begin with the design alternative having the highest priority. If, through a preventive maintenance program, a site can adequately provide for expected user demands, then this alternative should be used; further examination of other alternatives is unnecessary.

If it is impossible to achieve program objectives without design intervention, the highest priority long-term design option should be examined. In most cases this will mean stabilization of the existing form and detailing of site elements. Only if this is unworkable should one move on to rehabilitation and restoration as serious options. Because they can cause more damage and irreversible change to existing fabric, controls are somewhat stricter. If these options are impossible to work with, replacement in the form of contemporary or reconstructed elements may have to be examined.

In each case of functional assessment, projected program requirements for the site should be made as flexible as possible to avoid drastic design interventions necessitated by minor or arbitrary use projections. Some use requirements such as public safety provide very little leeway; others such as the extent of public access or the nature of the interpretive display should be moderated, particularly if a small trade-off will allow the design intervention to remain in a high priority category.

Costs are also a factor. By policy, the cost-benefits of restoration and reconstruction in particular must be documented. In many cases, lower costs will be correlated with higher priority design alternatives, reinforcing the advantages of a conservative approach to site alterations.

4.5 SELECTION OF DESIGN APPROACH

That approach which is highest on the priority list and acceptable from the standpoint of functional assessment should be selected as the basis for formal design activity.

The method of design selection should help ensure that the commitment to the protection of existing historic resources is

The Fortress of Louisbourg, NS

reflected in the actual evolution of design decision by the project team and that public understanding, appreciation and enjoyment are provided for in ways which leave these resources, so far as possible, unimpaired.

5.0 CONCLUSION

The process of design evaluation has been described in terms of overall project direction. Once this direction has been set, smaller scale decisions, as mentioned previously, can be made using basically the same process of elimination. Decisions concerning the maintenance, adaptation or replacement of individual elements, or concerning the choice of one conservation technique or strategy over another, should be made with the same reference to a prioritized set of alternatives, with protection of existing resources the governing factor.

Site Animation, Fortress of Louisbourg, NS

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

3.1
INTERIM PROTECTION
DESIGN STANDARDS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: JULIAN SMITH

CONTENTS

1.0 INTRODUCTION

This article describes short-term conservation techniques used to provide temporary consolidation and protection of historic sites and structures while they await long-term development.

2.0 BACKGROUND

Historic sites and structures are continually subject to the forces of deterioration and change. Although maintenance effectively controls many problems, particularly those associated with dirt and abrasion, more significant physical intervention is required periodically to stabilize or upgrade a historic site or structure.

Intervention as part of a major development phase of a project can involve extensive, irreversible physical changes often designed not only to eliminate behavioral weaknesses but also to satisfy other program objectives such as site commemoration. Such intervention presupposes major analysis and research.

Intervention required on short notice or on its own without supporting research and development calls for short-term conservation techniques. They are most often needed in the following instances.

a. Following site acquisition:
   Immediate protective and stabilization measures may be required after initial site inspections, but before full property research and design can begin.
b. In response to emergencies:
   During either pre-development or post-development phases of a project, unexpected signs of deterioration or damage from a catastrophe may call for a holding action while long-term solutions for preservation are being developed.
c. As part of maintenance:
   Interim measures to upgrade the maintenance characteristics of a site or structure may be implemented and coordinated with regular maintenance.

In every case, these short-term techniques are designed to arrest decay through non-destructive or reversible treatment of the historic fabric.

3.0 TYPES OF SHORT-TERM CONSERVATION TECHNIQUES

3.1 STRUCTURAL CONSOLIDATION

Structural stability is a prelude to other forms of protection. Structural movement not only endangers the historic fabric but also makes environmental controls, and fire and vandalism protection difficult to implement and maintain.

Most interim structural consolidation techniques involve external bracing (that is, external to the fabric itself; bracing may, however, be located inside a structure). Although visually disruptive, bracing minimally damages the physical resources and can often be dismantled with relative ease. Low-pressure grouting for masonry or stiffening selected members in wood framing may also prove acceptable, but more permanent internal reinforcement techniques such as epoxy injections, dowel reinforcements and secondary integrated support systems should be avoided. They are generally irreversible and constrain future research and development options.

External bracing requires basic structural analysis of those parts showing signs of deformation and stress. The bracing elements must minimize any damage to the historic fabric points of contact and not unduly hamper site activity and, in some cases, be easy to dismantle.

If the cause of the structural weakness can be determined and removed, bracing may be avoided. Loading conditions are sometimes alterable and various environmental control measures such as changing drainage patterns or preventing freeze-thaw cycles may help (see 3.2).

3.2 ENVIRONMENTAL CONTROL

Interim environmental control measures protect against gradual and sudden decay.

The control of water infiltration is the most important requirement. High humidity and moisture levels encourage chemical and biological attack and damaging freeze-thaw cycles. They may be combatted by, for example, repairing roofing materials

Riel House, St. Boniface, MB

and flashings, fixing and cleaning gutters and downspouts, sealing openings and installing perimeter drainage systems or, for a dilapidated or delicate structure, providing an entire secondary roof or full enclosure. Whatever the solution, the goal is to ensure that all water is adequately shed from a structure and drained away.

Even with an external seal against water infiltration, humidity levels inside a structure can still present a problem. Sudden variations in temperature and humidity may cause damage. Overheating causes brittleness and shrinkage to interior finishes and condensation of water vapour due to high humidity levels may encourage biological decay.

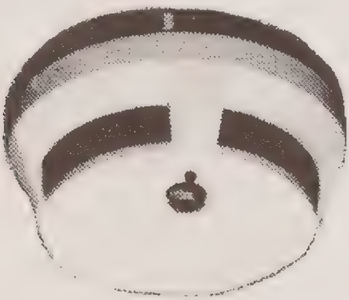
Heating and ventilating are used to control humidity. Temporary heating systems decrease relative humidity and prevent condensation; they also protect against damage from temperature variations. If the structure is unoccupied, design the system to keep the interior above the freezing point (0-5°C) during winter and at 10°C in the spring and fall.

Note: Even temporary heating systems must be installed in accordance with fire and safety codes and a daily site inspection made to the structure.

Ventilation controls humidity by ensuring constant air change, thereby preventing build-ups of high relative humidity and resulting condensation. If a structure is unheated, provide openings for ventilation to all interior spaces at the rate of approximately one percent of the floor area. Include all confined spaces, especially those against the ground surface. Similarly ventilate unheated areas of an otherwise heated structure and all structures during summer.

Effective control of humidity and moisture will counteract most insect and fungal attacks. However, where infestation already exists, use fungicides and insecticides. Where diseased material must be removed, first notify specialists in the various disciplines that might be involved in future site research.

Sunlight, wind, air pollution and vibration are also possible causes for concern. Shading from sunlight may be required for painted surfaces and other materials and fabrics containing fugitive pigments or other ingredients subject to damage from ultra-violet radiation. Protection from wind may involve refastening exterior architectural elements such as decorative woodwork and ironwork, sheet metal finishes and chimneys. Control of air pollution is normally beyond the scope of short-term conservation measures, but may need to be considered if there is a major local source of pollution generating, for example, sulfate, which causes considerable damage. Vibration endangers both general structural security and delicate finishes and may require such measures as rerouting heavy traffic.



Smoke Alarm

3.3 PROTECTION FROM FIRE AND VANDALISM

Fire and vandalism are usually greater threats for a site or structure under interim development. Vacancy, disuse and accumulated discarded, damaged or stored materials all contribute to the vulnerability of the site. Temporary fire detection or protection systems must therefore be installed if none exist and adequate vandalism measures instituted.

A fire detection and alarm system provides the minimal protection for any structure, whatever its phase of development. Temporary detection devices hooked up to the local fire station or other responsibility centre may suffice. Consider also the methods of fire suppression such as hand-held extinguishers available on site and, in the case of invaluable or vulnerable resources, temporary sprinkler systems laid out using existing openings and circulation spaces.

For protection against vandalism, restrict physical access to the site and make the structure as presentable as possible. The site should appear to be functioning rather than disused and in disarray. Prepare temporary window and door coverings (plywood panels are commonly used) to give the appearance of window sashes, door eaves or other replaced materials, as appropriate. Secure loose elements and control landscape features. None of these measures should, however, alter the configuration or finish of historic materials.

3.4 LANDSCAPE CONTROL

Built elements in the landscape such as street furniture, signs and fences use interim protection techniques similar to those discussed above for other structural units. Vegetation, including the many varieties of ground covers, requires more ongoing protection, but the protection must not only safeguard the vegetation but also prevent it from encroaching on historic structures. Although growth and decay cannot be halted, measures such as selective pruning, controlling weeds and pests and providing adequate drainage can stabilize a situation sufficiently to ensure that evidence of historic patterns is not lost and future analysis and development activity is not prejudiced. Temporary physical barriers and alternate access routes may be required during property research or interim maintenance to prevent inadvertent damage to surface and subsurface features.

Landscape Control

4.0 MOTHBALLING

Mothballing itself is not a technique, but a program of intervention using different methods to prevent the deterioration of an unused or vacant structure.

Structural security, environmental control, fire and vandalism protection and landscape control are all important in designing the mothballing program. Normally, a successful program also relies heavily on maintenance to offset the ongoing attacks of dirt and wear; to monitor the success of the protective measures implemented; and to detect new and unsuspected forms of decay.

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Articles in Vol. III provide more information on short-term conservation techniques.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

3.2
INTERIM PROTECTION
STABILIZATION OF HISTORIC STRUCTURES

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ORIGINAL DRAFT: CLAUDE LEVESQUE

CONTENTS

1.0 INTRODUCTION

Historical structures are continuously subject to forces of deterioration and change. Cyclical maintenance routines provide an effective way of controlling many of these problems. Periodically, however, more significant physical intervention is required to stabilize or upgrade a site.When the intervention is required on short notice or as an isolated event, conservation techniques are needed.

Adequate structural stability is a prerequisite for other forms of protection. Active structural movement not only endangers the historic fabric, but makes environmental control systems and protective measures against fire and vandalism difficult to implement and maintain.

2.0 INTERIM STRUCTURAL STABILIZATION

Interim structural consolidation techniques involve bracing and shoring systems which are external to the fabric itself. Although visually disruptive, this approach allows for minimal damage to the fabric and can often be dismantled with relative ease. Bracing and shoring systems require basic structural analysis of the parts of the structure showing signs of deformation and/or stress. The following points should be considered in the design.

a. Minimal damage to the historic material:
Whenever possible, lay out bracing and shoring systems to provide maximum efficiency without dismantling parts of walls or floors to accommodate them.

b. Provision of access for continuous site activity:
Make adequate allowance for the movement of investigators working on long-range development plans. Incorporate alternate access routes in the design, when necessary. Provide sufficient clearances for implementing anticipated permanent stabilization designs.

c. Ease of dismantling:
The original design of the bracing or shoring should allow dismantling to be as non-destructive as possible.

d. Nature of deformations:
Deformations may sometimes be permanent, as in the case of a wooden beam overstressed for a long period of time. Moreover, deformations may have historical significance. In such events proper corrective measures will be determined at the restoration design phase. Thus the bracing or shoring system should be designed to stabilize the deformations rather than to correct them.

3.0 TYPES OF BRACING SYSTEMS AND APPLICATIONS

In this publication "bracing" means any temporary support installed in an excavation or structure to increase the rigidity in the longitudinal and/or transversal axes to stabilize against deformations.

The belt bracing system shown in Figs. 1 and 2 has the function of stabilizing the stone masonry walls against further movement outward. A belt, consisting of 38 mm x 89 mm wall pieces and 89 mm x 89 mm walers, surrounds the building. Tie rods with turnbuckles restrain the walers affixed to opposite exterior walls. This system was used to stabilize the walls of House 40 in Artillery Park in Quebec City. At the design phase it was decided to consolidate the walls in their state of deformation. Such a bracing system may also be used to plumb walls, but the operation should be monitored carefully. Of two opposite exterior walls the one may be weaker or less deformed and thus would reach plumb first. At that stage the operation should be stopped and other means should be used to plumb the remaining wall.

The flying shore shown in Fig. 3 is actually a bracing system according to the previous definition. It gives a defective wall support from a parallel sound wall by providing a thrust that is opposite to the disturbing force and does not rely on ground support. It differs from the above system by acting in compression rather than tension. The sound wall must be no more that 8100 mm away and complications arise if the floors in the two buildings are not at the same level. If they are not level, take considerable care to apply the shores as equally between them as possible and use very stiff wall pieces to act as beams spanning from floor to floor. The wall pieces are cut to take needles and cleats as shown in Fig. 12. Use folding wedges to tighten the system carefully with the least vibrations to bear against the wall pieces.

The timber bracing system illustrated in Figs. 4 to 8 is mainly used when a building has become dangerous due to severe deformations, foundation movement, deterioration or overstress of main structural elements. Although it can relieve the structure of vertical loads and thus be considered as a shoring system, its main purpose is to increase the rigidity about the longitudinal and transversal axes with two sets of interconnected frames running along these axes. This system has been used to stabilize the severely deformed Winaut's Store in Dawson, YT. Major foundation work had to be carried out requiring the temporary relocation of the building. Rigidity was provided by the bracing system to ensure safe movement of the structure.

It is important when laying out the system to fit a series of frames to the interior periphery of the exterior walls. The exterior walls are then "sandwiched" between the bracing frames and walers installed outside the walls as shown in Figs. 5 and 7. If the building is more than one storey, install bracing frames on each floor and continuous exterior waling to ensure proper vertical fastening between the frames. A schedule for sizes of frame members is given in Fig. 8.

The bracing systems discussed above are mainly used in buildings. Other systems, such as those shown in Figs. 9 and 10, are for use in excavations. The soldier piles are usually rolled-steel, broad-flanged beams driven before excavating from ground level to depth 1000 – 2000 mm below the bottom of the excavation. As the excavation is taken down, timber polings (lagging) are inserted horizontally between the flanges of the piles and held against the face by wedges. It is necessary to excavate by increments of two or three boards to provide enough space to slip one board from the bottom of the excavation. In water-bearing ground, leave narrow gaps between the poling boards to allow drainage, thereby avoiding build-up of hydrostatic pressure behind the timbering. In a large excavation the struts are replaced with beam rakers to provide lateral thrust to the soldier piles as illustrated in Fig. 10. It should be noted that although sheetpiling could be considered an alternative to the above systems, it involves a considerably longer duration of vibration during the driving operation, which increases the chance of harm to the nearby historic structures. Therefore, avoid the use of sheetpiling whenever possible.

4.0 TYPES OF SHORING SYSTEMS AND APPLICATIONS

In this publication "shoring" means any temporary support installed in an excavation or structure to relieve the vertical and/or horizontal loads to permit alterations or repairs to the foundation or main supporting elements.

Shoring should be carefully designed so that when the time comes to transfer the weight of the structure to be supported to it, this can be done without any jarring whatever. This means that the shoring must be wedged tightly before any other work is carried out. The weight of the structure supported must be transferred through the shoring to suitable reaction points forming a rigid base. Since shoring is taken to ground level it is important that suitable consideration be given to spreading the load according to the capacity of the soil to sustain it. In addition, shoring must be designed to allow clear space for repair and bringing in of materials and, in the case of dead shoring, be sufficiently strong to provide for the attachment of hoisting gear.

Shoring can be divided into two main types. A raking shore is erected to provide lateral support and sustain vertical loading. Dead shoring, is erected to relieve vertical loading of walls and floors while repair work is being carried out below.

The typical raking shore shown in Fig.11 is usually erected at each end of the wall to be supported and at 3500 – 4500 mm o.c. along the length of wall. Shores should also be erected at each corner in line with the wall. Raking shores should be single lengths but, if not available, it is recommended that a proper splice detail be used, such as that shown in Fig. 13. If it is necessary to splice more than one raker in a system of shores, the splices should not be opposite each other and each splice should be provided with lacings. In shoring a wall which is "alive", i.e. still moving, it may be necessary to erect temporary jigs, each consisting of an upright against the wall with a raker notched in.

These jigs can be put up off the line of the shoring while holes for the needles are being cut and other work prepared for raking shores. The needle detailing is shown in Fig. 12.

A typical dead shore is illustrated in Fig. 14. Its prime function is to relieve the masonry wall of its load to permit alterations or repairs where required. The principle of needle support is based on the fact that reasonably sound brickwork will support itself by a corbelling action over a distance of about 1500 – 1800 mm. Needles may have to be placed closer than 1500 mm o.c. if the condition of the brickwork warrants it. Needles must always be positioned under piers and never below windows and doors, which should be strutted. In old stone walls, it may be necessary to position the needles much closer, possibly as close as 100 mm o.c. and great care must also be taken to ensure that a loose and friable core does not run out. In some cases it may be advisable to consolidate the wall by grouting the core, before installing dead shores. In other cases boards may be slid into position to prevent the core from escaping. The needle should be as short as possible, but an allowance of 750 mm is necessary on each side of the wall as working space. Lacing should be fixed between the posts to prevent sway.

Columns of framed structures can be shored up individually by needle beams. Cleats are bolted or welded to the opposite flanges to provide bearing to the needles as shown in Fig. 15. Reinforced concrete or brick columns can be supported by girts tightly bolted around them and prevented from slipping by chases cut in the faces of the columns as shown in Fig. 16. Cast-iron columns are shored with the use of steel pins and a steel collar bolted near the top of the column as illustrated in Fig. 17. Prior to shoring, fill the column with cement grout through a hole cut at the top of column. This strengthens the pins and secures the column against the collapse from compression induced by the steel collar, combined with the stresses upon the column from its load.

Hydraulic jacks must be installed between needle beams and girts, cleats and collar. The pressure from jacks is increased progressively until upward movement of the column is just detected. This process is called prestressing; it allows for repair or underpinning of the foundation of the column. Constant monitoring of hydraulic apparatus must be provided to detect pressure leaks.

4.1 SHORING SYSTEMS FOR ARCH REPAIRS

Depending on the type and extent of damage suffered, arches often require the use of a combination of different types of support as previously described. Among others, damage to arches is caused by:

a. cracking, collapse or buckling of an arch caused by an overload or an unequal burden;
b. a fire;
c. the partial charring of the curve of the arch due to movement of the columns or abutment or by removal of a stabilizing load; and
d. sinking in or lateral sliding of an abutment because of damage occurring in the foundation.

Temporary support procedures generally used for each type of damage are:

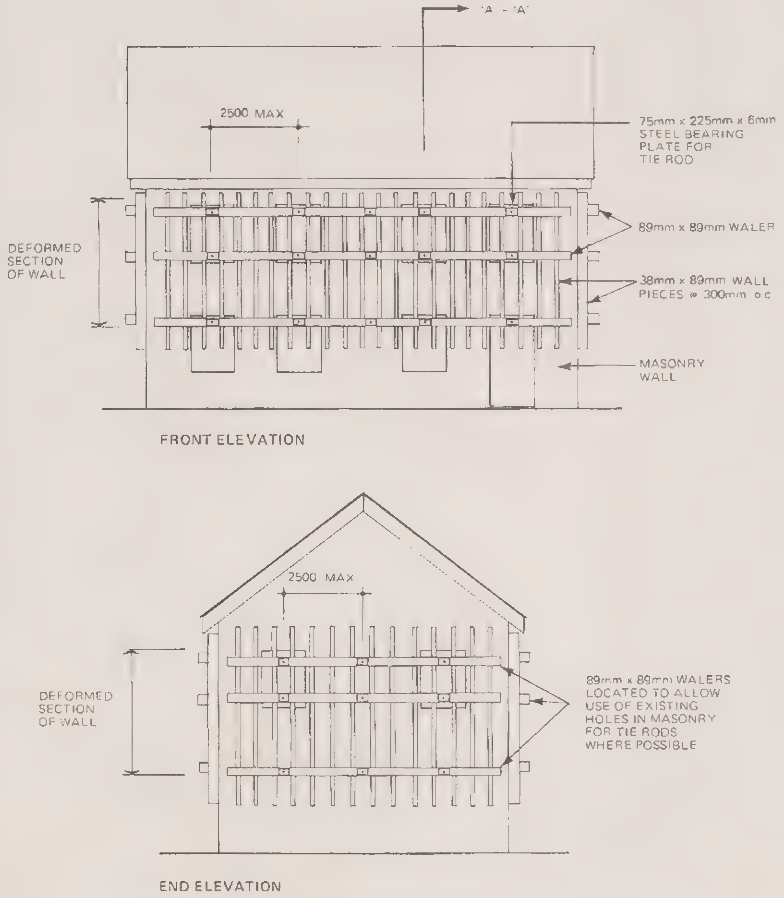
a. Damage Resulting from Overloading:
Generally an arch damaged by overloading will need to be partially rebuilt. To achieve this the load on the arch must be removed using a dead shoring. The sections which are in good condition must also be shored up during the course of reconstruction. To this purpose the same type of framework must be used as in the construction of a new arch and it should be steadied into position as illustrated in Fig. 18. Once the arch has been realigned, any defects in the brickwork or masonry above the arch should also be repaired, but the shoring should be left in position until the mortar has had a reasonable time to set and harden. The load on the needles should then be relieved gradually and without shock, by cautious removal of the wedges. The centering (formwork) should be progressively lowered by loosening the wedges until downward movement of the arch ceases.

b. Damage by Fire:
Where an arch has been subjected to intense heat, the damage usually takes the form of discolouration, cracking and spalling on the arrises. Discolouration without cracking or spalling can be regarded as superficial and can be ignored. If cracking is extensive, the arch should be relieved of its load and centred as described above, before repairs are made.

c. Damage to Abutments by Displacement:
Where the stability of an arch is endangered by damage to the piers or abutments it depends on for support, the first step is to arrest further spread of the arch by tying the abutments as near as possible to the springing level of the arch. As an emergency measure, tie-rods and turnbuckles will usually provide the necessary check as shown in Fig. 19. The arch should then be shored and centred before repairs are made.

d. Damage by Subsidence of Abutments:
Where an arch is in danger because of damage to one or both abutments by foundation failure, take the steps described in the previous section but carry all temporary supports some distance away to leave the foundations accessible for examination and repair. A suitable arrangement for shoring and centring is shown in Fig. 20.

5.0 ILLUSTRATIONS: FIGS. 1-20



EXTERIOR BELT BRACING FOR BUILDINGS

Figure 1

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING 1 of 2			N.T.S.
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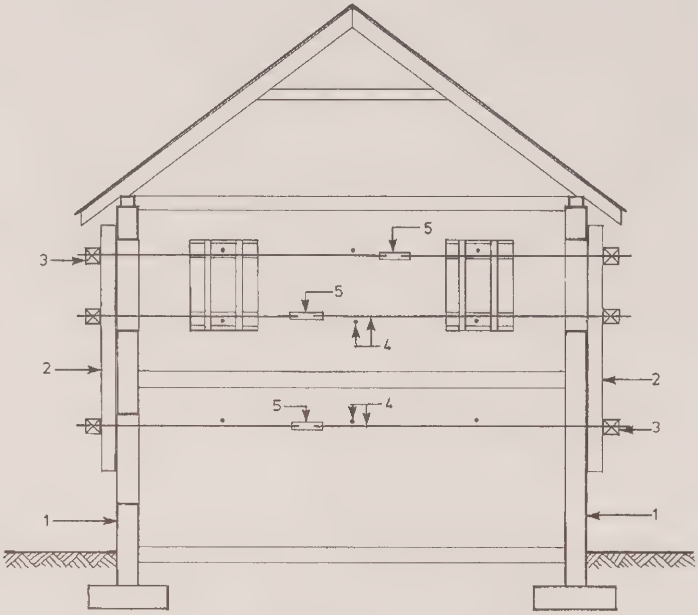

SECTION 'A'- 'A'

LEGEND:

1. MASONRY WALL
2. 38mm x 89mm WALL PIECES
3. 89mm x 89mm WALERS
4. 13mmø MIN. STEEL TIE RODS
5. TURNBUCKLES

NOTE:

DIMENSIONING AND SPACING OF TIE RODS, WALERS AND WALL PIECES DEPEND ON THE NATURE OF THE WALLS AND THE STATE OF DEFORMATION. ALL FIGURES GIVEN ABOVE ARE FOR GUIDANCE ONLY.

EXTERIOR BELT BRACING FOR BUILDINGS *Figure 2*

TITLE / TITRE: SHORING AND BRACING	2 of 2	SCALE / ECHELLE: N.T.S.
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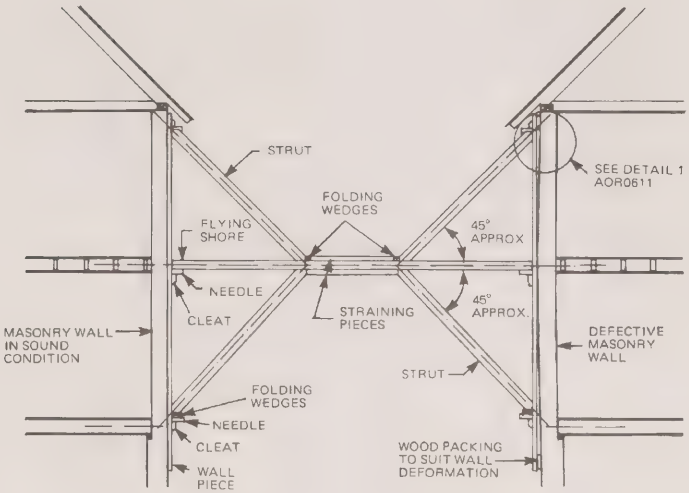


NOTE

A. THE CENTRE LINE OF FLYING SHORE TO COINCIDE WITH CENTRE LINE OF FLOOR JOISTS AS SHOWN.

B. AT WALL, CENTRE LINE OF STRUTS TO INTERSECT CENTRE LINE OF FLOOR JOISTS OR UNDERSIDE OF WALL PLATE

C. FLYING SHORES TO BE ERECTED NEAR ENDS OF THE WALL AND AT INTERVALS OF 2500 - 3500mm o.c.

D. IT IS MANDATORY THAT ONE OF THE WALLS BE IN SOUND CONDITION TO PROVIDE SUFFICIENT LATERAL THRUST TO THE DEFECTIVE WALL.

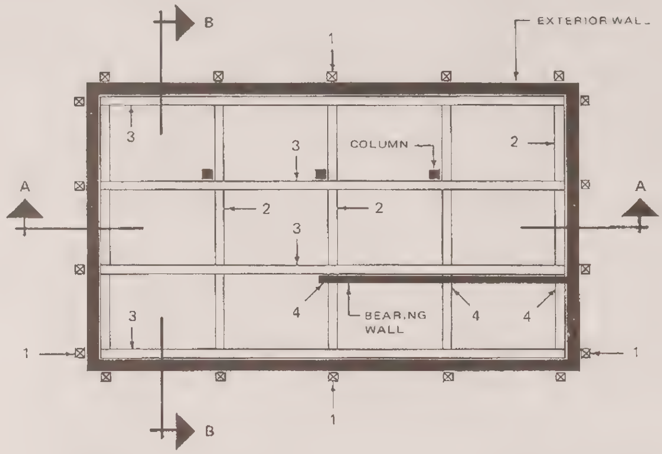
E. SIZE OF FLYING SHORES AND STRUTS

SPAN	FLYING SHORE	STRUT
up to 4500mm	89mm x 140mm	89mm x 89mm
4500 - 9000mm	140mm x 140mm to 216mm x 216mm	89mm x 140mm to 89mm x 216mm

FLYING SHORES

Figure 3

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING			N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE REST. SERV.	CHECKED BY / VERIFIE PAR G.A.H./C.A.L.	DATE / DATE 79 . 10 . 26
	DRAWN BY / DESSINE PAR JAN SKLENAR/P.B.	REFERENCE No. / No. DE REFERENCE AOR0601A1	



PLAN

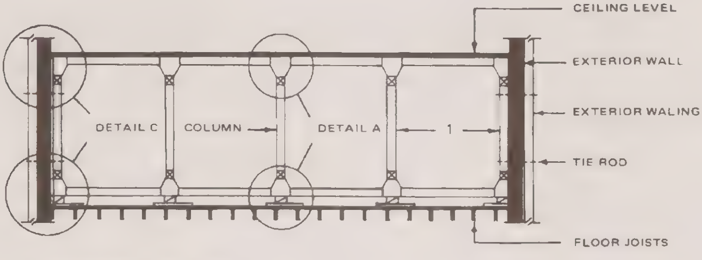
LEGEND·

1. EXTERIOR WALING
2. TRANSVERSAL BRACING FRAME SPACED AT 2000mm — 2500mm o.c.
3. LONGITUDINAL BRACING FRAME SPACED AT 2000 - 2500 o.c.
4. FRAME MEMBERS INSTALLED THROUGH BEARING WALL

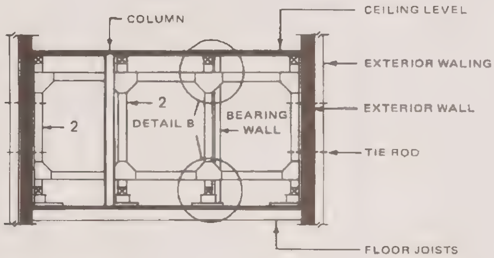
TIMBER BRACING FRAME SYSTEM FOR BUILDINGS

Figure 4

TITLE / TITRE BRACING AND SHORING	SHEET 1 OF 5		SCALE / ECHELLE N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE REST.	CHECKED BY/ VERIFIE PAR G.E.S.	DATE / DATE 79 . 9 . 29
	DRAWN BY/ DESSINE PAR J.S./G.W.	REFERENCE No. / No. DE REFERENCE AOR0602A1	



LONGITUDINAL SECTION A - A

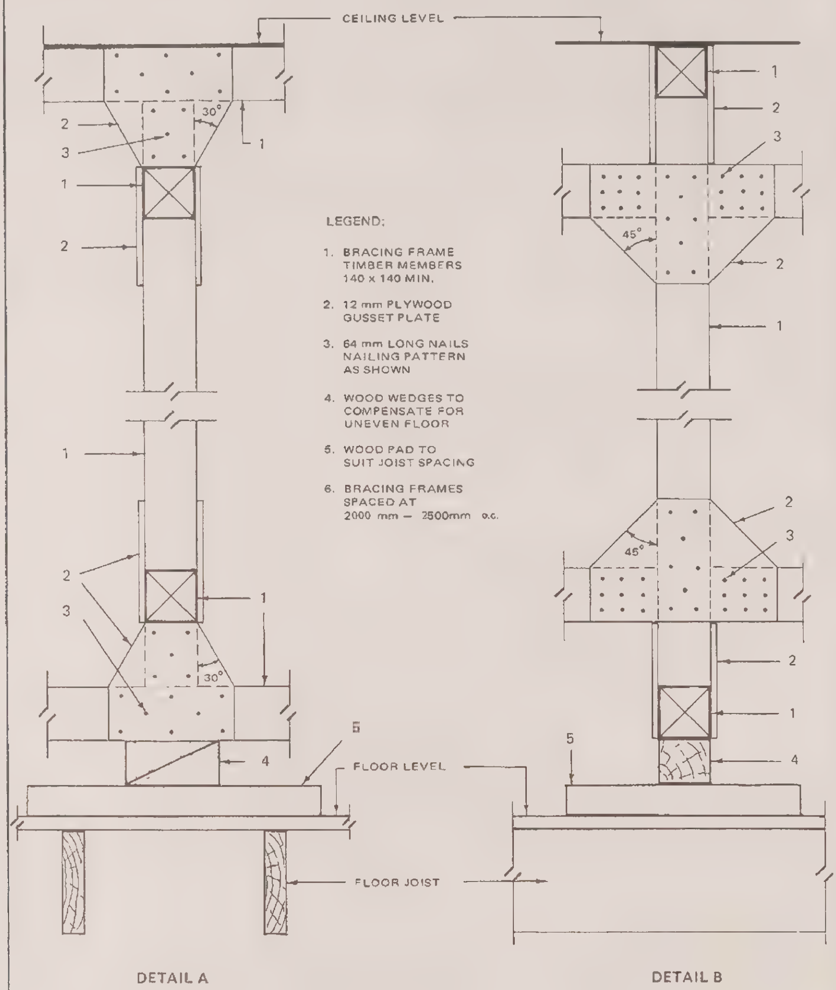


TRANSVERSAL SECTION B - B

NOTE:
IF THE BUILDING IS MORE THAN ONE STOREY,
FRAMES TO BE INSTALLED ON EACH FLOOR
AND TO BE CONNECTED TO OTHER VERTICAL FRAMES
BY PROVIDING CONTINUOUS EXTERIOR WALING.

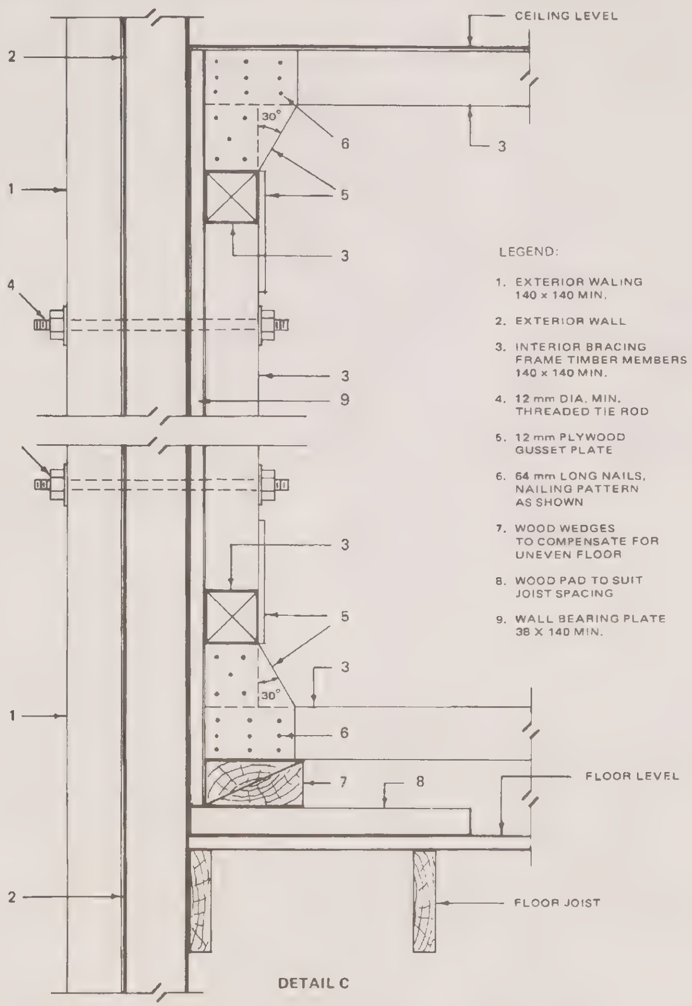
TIMBER BRACING FRAME SYSTEM FOR BUILDINGS *Figure 5*

TITLE / TITRE BRACING AND SHORING		SHEET 2 OF 5	SCALE / ECHELLE N.T.S.
Parks Canada / Parcs Canada	SOURCE / RESOURCE REST. SERV.	CHECKED BY / VERIFIE PAR G.E.S.	DATE / DATE 79 . 9 . 29
	DRAWN BY / DESSINE PAR J.S./G.W.	REFERENCE No. / No. DE REFERENCE AOR0602A1	



TIMBER BRACING FRAME SYSTEM FOR BUILDINGS *Figure 6*

TITLE / TITRE BRACING AND SHORING		SHEET 3 OF 5	SCALE / ECHELLE N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE REST. SERV.	CHECKED BY / VERIFIE PAR G.E.S.	DATE / DATE 79 . 9 . 29
	DRAWN BY / DESSINE PAR J.S./G.W.	REFERENCE No. / No. DE REFERENCE AOR0602A1	



TIMBER BRACING FRAME SYSTEM FOR BUILDINGS *Figure 7*

TITLE / TITRE BRACING AND SHORING		SHEET 4 OF 5	SCALE / ECHELLE N.T.S.
Parks Canada / Parcs Canada	SOURCE / RESOURCE REST. SERV.	CHECKED BY / VERIFIE PAR G.E.S.	DATE / DATE 79 . 9 . 29
	DRAWN BY / DESSINE PAR J.S./G.W.	REFERENCE No. / No DE REFERENCE AOR0602A1	

DIMENSIONING SCHEDULE FOR BRACING ELEMENTS:

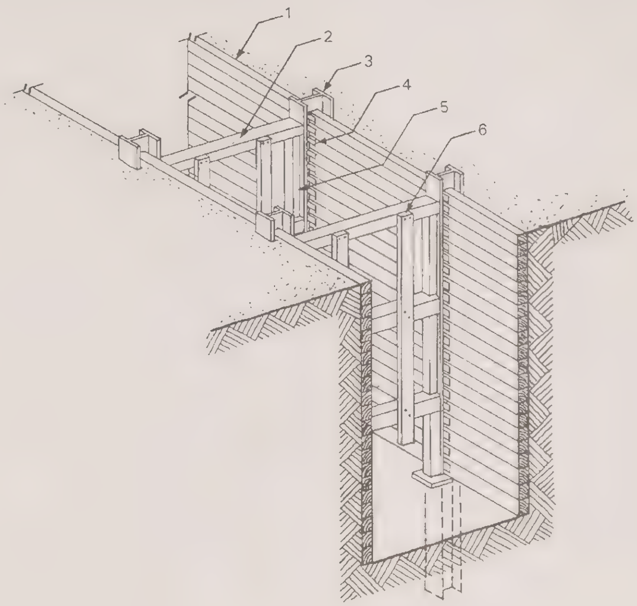
POST SPACING	BEAM SIZE	POST SIZE	PLYWOOD GUSSET PLATE THICKNESS	NUMBER OF NAILS REQUIRED – 64mm LONG MIN.
0mm – 3000mm	140x140	140x140	13mm	13
3000mm – 4500mm	140x184	140x140	13mm	15
4500mm – 6000mm	184x184	140x184	13mm	15 – 19
6000mm – 9150mm	235x235	184x235	19mm	18 25

NOTE
FRAME INSERTED FIGURES WERE USED IN DETAILING THIS SERIES OF DRAWINGS.

TIMBER BRACING FRAME SYSTEM FOR BUILDINGS

Figure 8

TITLE / TITRE			SCALE / ECHELLE
BRACING AND SHORING		SHEET 5 OF 5	N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE: RESTORATION	CHECKED BY / VERIFIE PAR: G.E.S.	DATE / DATE: 79 . 09 29
	DRAWN BY / DESSINE PAR: G E S.	REFERENCE No. / No. DE REFERENCE: AOR0602A1	



LEGEND:

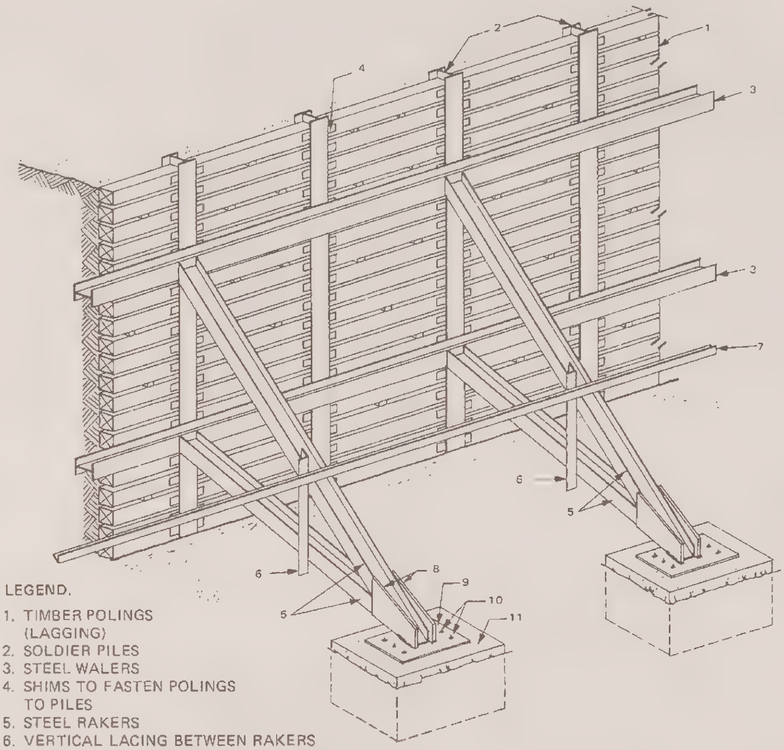
1. TIMBER POLINGS (LAGGING)
2. STRUT
3. SOLDIER PILE
4. SHIMS TO FASTEN POLINGS TO PILES
5. PUNCHEON, 89 x 89 MIN.
6. LACING 38 x 241 MIN.

NOTE:

1. DRIVE SOLDIER PILES AT 3000 mm - 4000 mm o.c. TO A DEPTH OF 1000-2000mm BELOW BOTTOM OF EXCAVATION.
2. EXCAVATE BY INCREMENTS OF TWO TO THREE POLING BOARDS AND INSERT BOARDS FROM BOTTOM OF EXCAVATION.
3. IN WATER-BEARING GROUND PROVIDE NARROW GAPS BETWEEN POLINGS TO ALLOW DRAINAGE.
4. THE DIMENSIONING OF PILES, POLINGS AND STRUTS DEPENDS ON THEIR RESPECTIVE SPACINGS, LENGTHS AND THE NATURE OF SOIL TO BE RETAINED.

BRACING SYSTEM FOR TRENCH EXCAVATION *Figure 9*

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING			N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE RESTORATION	CHECKED BY / VERIFIE PAR G.E.S.	DATE / DATE 1979
	DRAWN BY / DESSINE PAR JAN SKLENAR	REFERENCE No. / No. DE REFERENCE AOR0603A1	



LEGEND.

1. TIMBER POLINGS (LAGGING)
2. SOLDIER PILES
3. STEEL WALERS
4. SHIMS TO FASTEN POLINGS TO PILES
5. STEEL RAKERS
6. VERTICAL LACING BETWEEN RAKERS
7. HORIZONTAL LACING BETWEEN RAKERS
8. STEEL GUSSET PLATES WELDED TO BEARING PLATES
9. STEEL BEARING PLATES
10. ANCHOR BOLTS 13mm ϕ MIN.
11. CONCRETE FOOTING

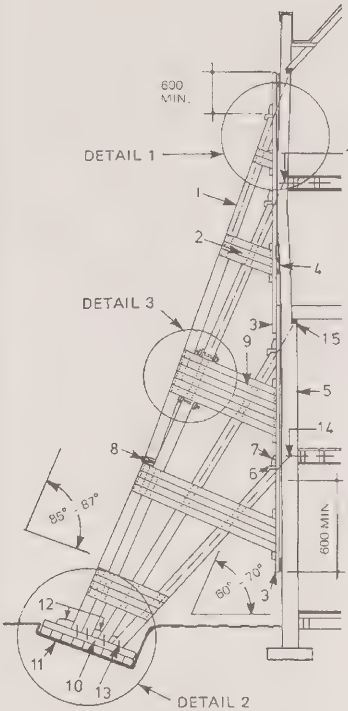
NOTE:

1. DRIVE SOLDIER PILES AT 3000 - 4000mm o.c. TO A DEPTH OF 1000 - 2000mm BELOW BOTTOM OF EXCAVATION.
2. EXCAVATE BY INCREMENTS OF TWO TO THREE POLING BOARDS AND INSERT BOARDS FROM BOTTOM OF EXCAVATION.
3. IN WATER-BEARING GROUND PROVIDE NARROW GAPS BETWEEN POLINGS TO ALLOW DRAINAGE, AS SHOWN.

BRACING SYSTEM FOR LARGE EXCAVATION

Figure 10

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING			N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE RESTORATION	CHECKED BY / VERIFIE PAR G.E.S.	DATE / DATE 1979
	DRAWN BY / DESSINE PAR JAN SKLENAR,	REFERENCE No. / No. DE REFERENCE AOR0604A1	



SIDE ELEVATION

LEGEND:

1. RAKER
2. LACING
3. WALL PIECE
4. PACKING TO FIT WALL
5. MASONRY WALL
6. NEEDLE
7. CLEAT FOR NEEDLE
8. FOLDING WEDGES AT BUTT JOINT
9. RAKER SPLICING
10. SOLE PLATE
11. TIMBER GRILLAGE
12. CLEAT
13. CAST IRON DOGS
14. CENTRE LINE OF RAKER TO INTERSECT CENTRE LINE OF JOISTS AT WALL PLANE
15. CENTRE LINE OF RAKER TO INTERSECT CENTRE OF WALL PLATE

NOTES:

A. RAKING SHORES TO BE ERECTED PERPENDICULAR TO THE WALL AT EACH END AND AT INTERVALS 3500 - 4500 mm o.c

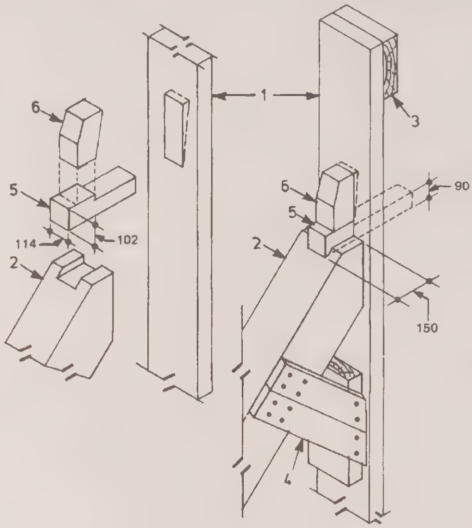
B. SIZE OF RAKERS FOR NORMAL BUILDINGS WITH MASONRY LOAD BEARING WALLS NOT EXCEEDING FOUR OR FIVE STORIES

HEIGHT OF WALL	RAKER SIZE (ACTUAL)
6000 - 9000 mm	165mm x 165mm
9000 - 12200 mm	191mm x 191mm
12200 - 15200 mm	241mm x 241mm

RAKING SHORES

Figure 11

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING		1 of 3	N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE REST. SERV.	CHECKED BY / VERIFIE PAR G.A.H./C.A.L.	DATE / DATE 79 . 10 . 26
	DRAWN BY / DESSINE PAR JAN SKLENAR/P.B	REFERENCE No. / No. DE REFERENCE AOR0605A1	



DETAIL 1

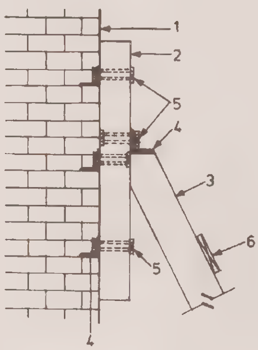
LEGEND:

1. WALL PIECE, 64 mm THICK WIDTH OF RAKER OR LARGER
2. RAKER
3. WOOD PACKING TO SUIT WALL DEFORMATION
4. 38mm X 89mm LACING
5. 102mm X 114mm HARDWOOD NEEDLE REBATED AT TOP TO 90mm X 114mm
6. 102mm X 114mm HARDWOOD CLEAT, BEVEL HOUSED 25 mm AND NAILED TO WALL PIECE

NOTES:

A. RECTANGULAR HOLE TO BE CUT IN THE WALL TO FIRMLY ACCOMMODATE NEEDLE. IF HOLE IS TOO BIG, RAM DRY CONCRETE PACKING TO ENSURE SNUG FIT BEFORE WALL PIECE IS ERECTED.

B. NEEDLE TO PROJECT AT LEAST 115 mm INTO THE WALL.



ALTERNATIVE DETAIL 1

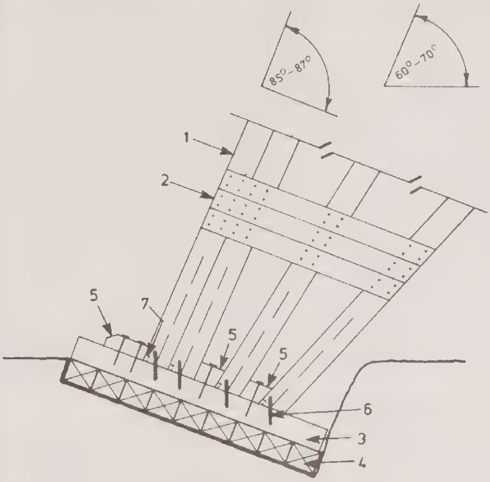
LEGEND:

1. EXTERIOR BRICK WALL
2. 140mm x 291mm TIMBER WALER
3. 291mm x 291mm RAKER
4. 19mm x 125mm x 125mm STEEL ANGLE
5. 19mm ϕ LAG BOLTS (RECESSED WHERE REQUIRED)
6. 38mm x 140mm LACING

RAKING SHORES

Figure 12

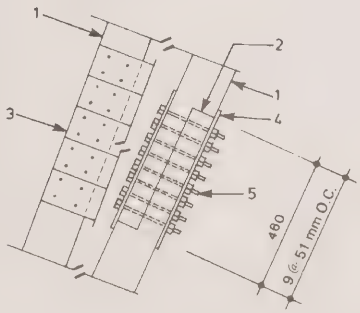
TITLE/TITRE SHORING AND BRACING		2 of 3	SCALE/ECHELLE N.T.S.
Parks Canada / Parcs Canada	SOURCE/RESOURCE REST. SERV.	CHECKED BY/VERIFIE PAR G.A.H./C.A.L.	DATE/DATE 79 . 10 . 26
	DRAWN BY/DESSINE PAR JAN SKLENAR/P.B.	REFERENCE No./No. DE REFERENCE AOR0605A1	



LEGEND:
1. RAKERS
2. 38mm X 140mm LACING
3. SOLE PLATE, 140mm X WIDTH OF RAKER
4. 140mm X 140mm GRILLAGE
5. CLEAT SPIKED TO SOLE PLATE
6. CAST IRON DOGS
7. NOTCH IN FOOT OF RAKER TO RECEIVE CROWBAR FOR LEVERING

NOTE:
FOR LEVERING, FOLDING WEDGES MAY BE USED INSTEAD OF NOTCHES AND CAST IRON DOGS.

DETAIL 2



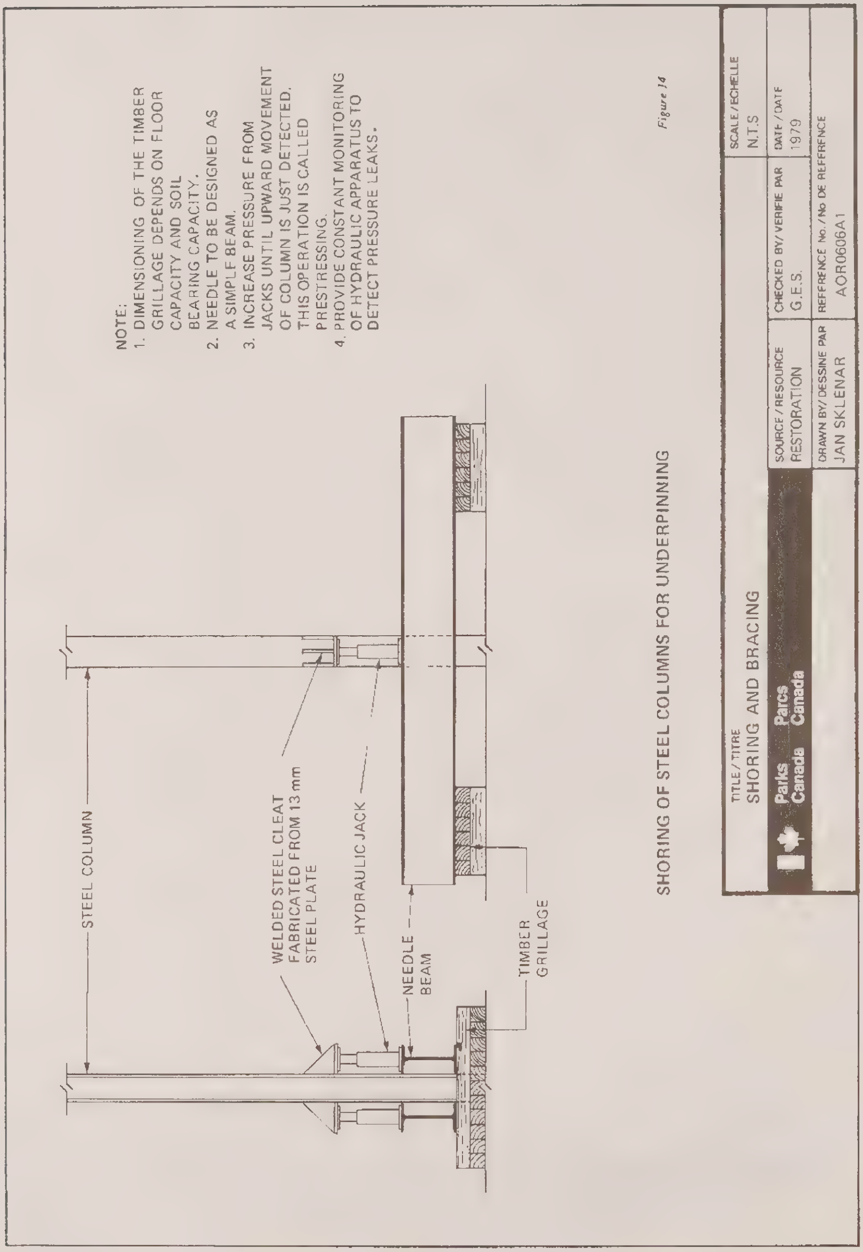
LEGEND:
1. RAKERS
2. HALF LAP SPLICE
3. 38mm X 140mm LACING
4. STEEL PLATE, 10mm X WIDTH OF RAKER
5. 13mmϕ LAG BOLT

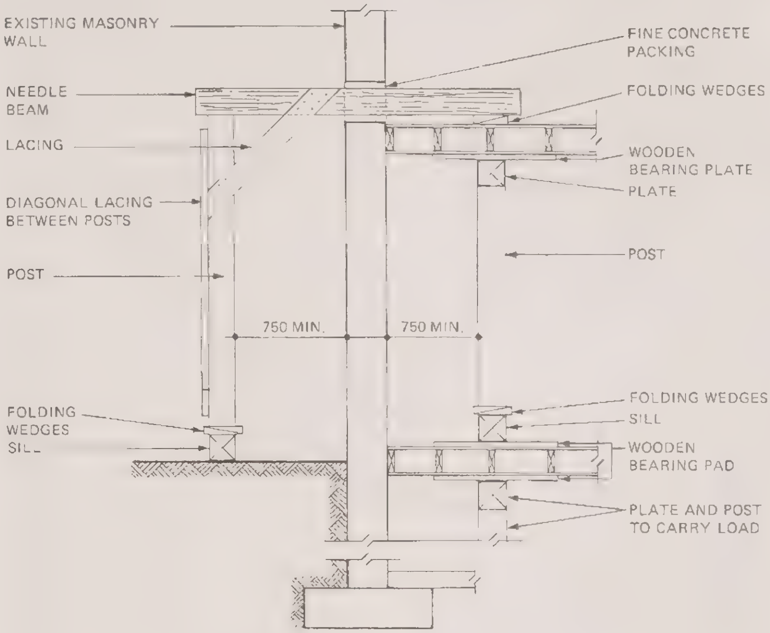
DETAIL 3

RAKING SHORES

Figure 13

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING 3 of 3			N.T.S.
Parks Canada / Parcs Canada	SOURCE / RESOURCE: REST. SERV.	CHECKED BY / VERIFIE PAR: G.A.H./C.A.L.	DATE / DATE: 79 . 10 . 26
	DRAWN BY / DESSINE PAR: JAN SKLENAR/P.B.	REFERENCE No. / No. DE REFERENCE: AOR0605A1	


STEEL COLUMN
WELDED STEEL CLEAT FABRICATED FROM 13 mm STEEL PLATE
HYDRAULIC JACK
NEEDLE BEAM
TIMBER GRILLAGE
NOTE:
1. DIMENSIONING OF THE TIMBER GRILLAGE DEPENDS ON FLOOR CAPACITY AND SOIL BEARING CAPACITY.
2. NEEDLE TO BE DESIGNED AS A SIMPLE BEAM.
3. INCREASE PRESSURE FROM JACKS UNTIL UPWARD MOVEMENT OF COLUMN IS JUST DETECTED. THIS OPERATION IS CALLED PRESTRESSING.
4. PROVIDE CONSTANT MONITORING OF HYDRAULIC APPARATUS TO DETECT PRESSURE LEAKS.
Figure 14
SHORING OF STEEL COLUMNS FOR UNDERPINNING
TITLE / TITRE
SHORING AND BRACING
Parks Canada Parcs Canada
SOURCE / RESOURCE
RESTORATION
CHECKED BY / VERIFIE PAR
G.E.S.
DATE / DATE
1979
SCALE / ECHELLE
N.T.S
DRAWN BY / DESSINE PAR
JAN SKLENAR
REFERENCE No. / No DE REFERENCE
AOR0606A1



NOTE:

1. USE ABOVE SYSTEM TO RELIEVE VERTICAL LOAD TO PERMIT LOCAL REPAIRS, ALTERATIONS OR REALIGNEMENT OF A DEFECTIVE MASONRY WALL OR ARCH, ALSO USE FOR FOUNDATIONS UNDERPINNING IN WHICH CASE THE NEEDLE IS TO BE INSTALLED AT GROUND LEVEL
2. NEEDLE TO BE DESIGNED AS BEAM IN FUNCTION OF LOAD AND SPAN
3. MASONRY IN SOUND CONDITION TO HAVE SHORES SPACED AT 1500mm o.c. MAX
4. UNIFORM BEARING OF LOAD ON NEEDLE TO BE PROVIDED BY PACKING, GROUTING OR LAYING A BED OF FINE CEMENT MORTAR PROPORTIONED · 1 CEMENT: 1 LIME · 6 AGGREGATE (SAND)
5. POSTS TO BE DESIGNED AS COLUMNS IN FUNCTION OF LOAD AND LENGTH.
6. INSIDE STRUCTURE, LOAD TO BE CARRIED TO FOUNDATION LEVEL BY USING PLATE AND POST AS SHOWN TIMBER GRILLAGE OR OTHER MEANS AS APPROPRIATE.

DEAD SHORING

Figure 15

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING			N.T.S
Parks Canada / Parcs Canada	SOURCE / RESOURCE: RESTORATION	CHECKED BY / VERIFIE PAR: G E S	DATE / DATE: 1979
	DRAWN BY / DESSINE PAR: JAN SKLENAR	REFERENCE No. / No DE REFERENCE: AOR0607A1	

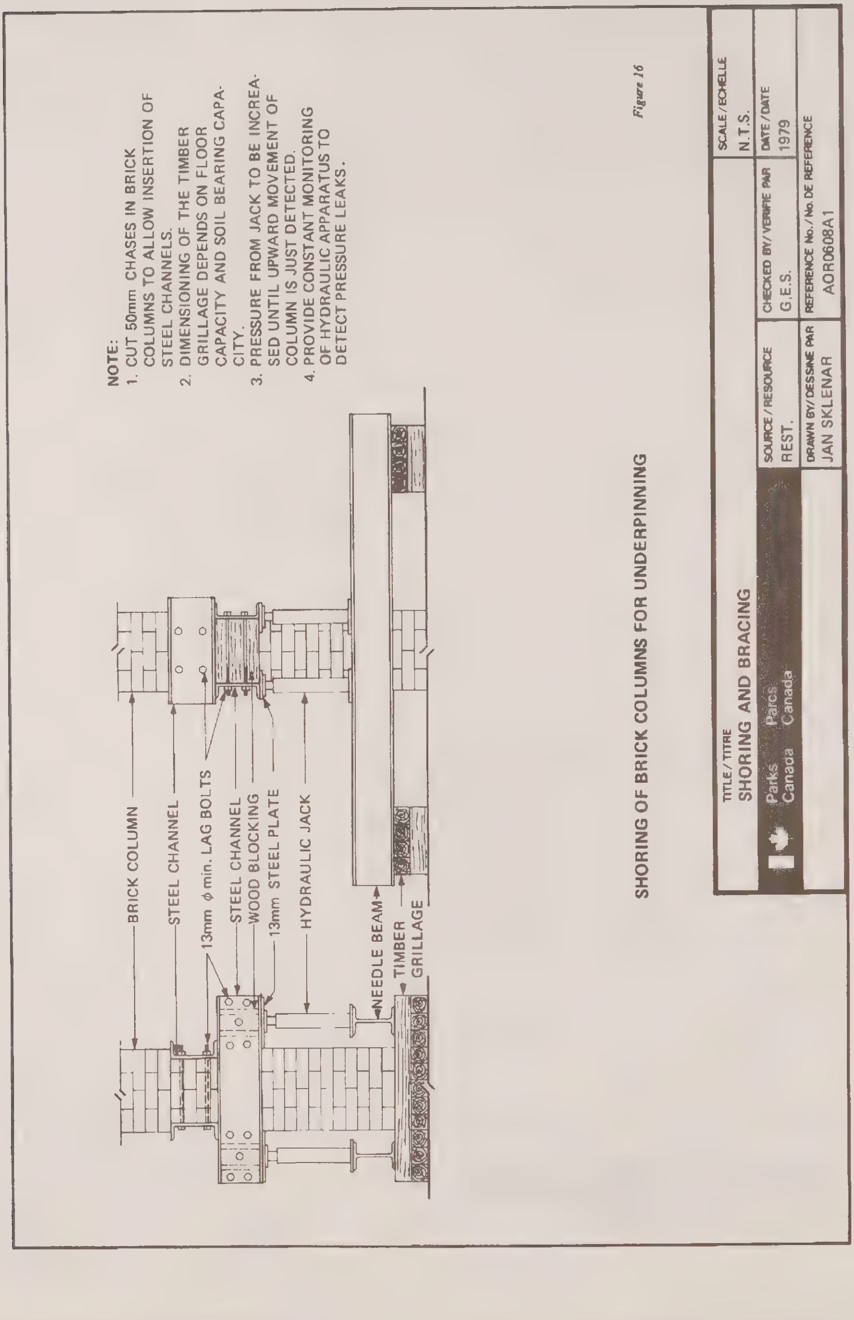

NOTE:
1. CUT 50mm CHASES IN BRICK COLUMNS TO ALLOW INSERTION OF STEEL CHANNELS.
2. DIMENSIONING OF THE TIMBER GRILLAGE DEPENDS ON FLOOR CAPACITY AND SOIL BEARING CAPACITY.
3. PRESSURE FROM JACK TO BE INCREASED UNTIL UPWARD MOVEMENT OF COLUMN IS JUST DETECTED.
4. PROVIDE CONSTANT MONITORING OF HYDRAULIC APPARATUS TO DETECT PRESSURE LEAKS.
BRICK COLUMN
STEEL CHANNEL
13mm φ min. LAG BOLTS
STEEL CHANNEL
WOOD BLOCKING
13mm STEEL PLATE
HYDRAULIC JACK
NEEDLE BEAM
TIMBER GRILLAGE
SHORING OF BRICK COLUMNS FOR UNDERPINNING
TITLE / TITRE
SHORING AND BRACING
Parks Canada
Parcs Canada
SCALE / ECHELLE
N.T.S.
SOURCE / RESOURCE
REST.
CHECKED BY / VERIFIE PAR
G.E.S.
DATE / DATE
1979
DRAWN BY / DESSINE PAR
JAN SKLENAR
REFERENCE No. / No. DE REFERENCE
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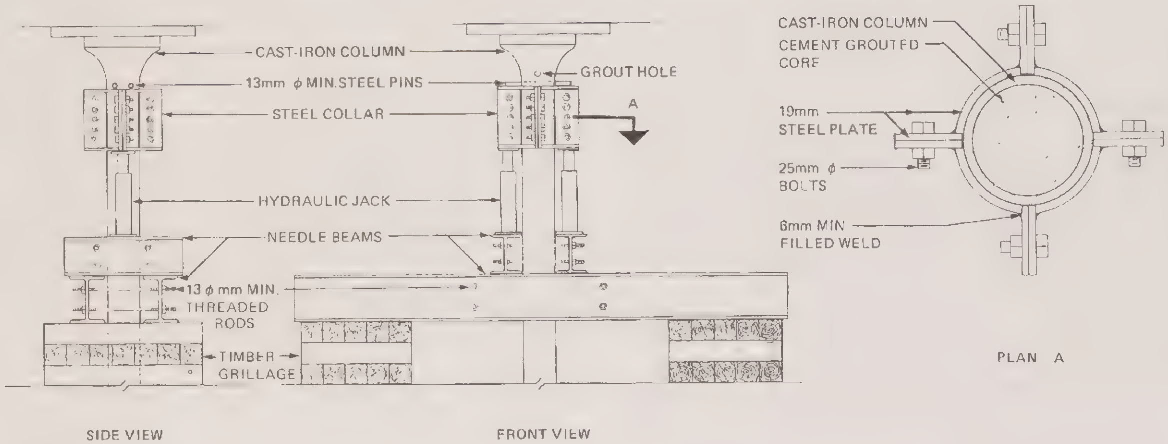
Figure 16

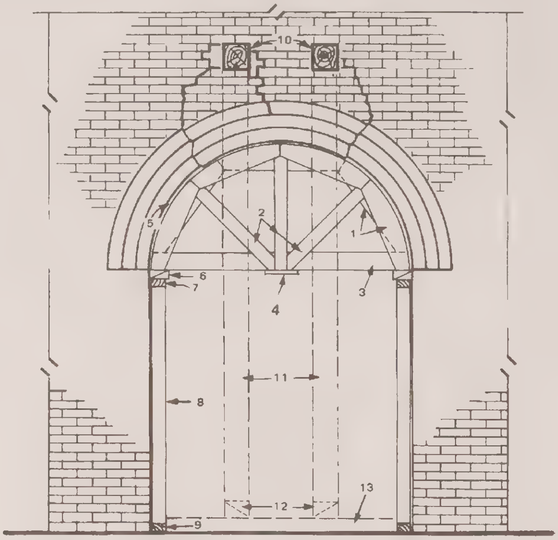


NOTE:
1 CUT HOLES AT TOP OF COLUMN AND FILL WITH CEMENT GROUT. ALLOW TIME TO SET.
2. CUT HOLES AND INSERT STEEL PINS. THE DIMENSIONING OF THE PINS DEPEND ON THE COLUMN LOAD, ALLOWABLE BEARING AND SHEARING STRESSES OF PINS AND COLUMN.
3. DESIGN NEEDLES AS SIMPLE BEAMS
4 DIMENSIONING OF TIMBER GRILLAGE DEPENDS ON FLOOR CAPACITY AND SOIL BEARING CAPACITY.
5 INCREASE PRESSURE FROM JACKS UNTIL UPWARD MOVEMENT IS JUST DETECTED.
6. PROVIDE CONSTANT MONITORING OF HYDRAULIC APPARATUS TO DETECT PRESSURE LEAKS

SHORING OF CAST–IRON COLUMNS FOR UNDERPINNING

Figure 17

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING			N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE: REST	CHECKED BY / VERIFIE PAR: G.E.S.	DATE / DATE: 1979
	DRAWN BY / DESSINE PAR: JAN SKLENAR	REFERENCE No / No. DE REFERENCE: AOR0609A1	



ELEMENTS OF CENTERING SYSTEM

1. 19mm PLYWOOD OFFSET TO INCREASE RIGIDITY.
2. DIAGONALS 38 x 140 MIN.
3. BOTTOM CHORD 38 x 241 MIN.
4. LACING BETWEEN CENTERING
5. 10mm PLYWOOD SHELL
6. FOLDING WEDGES
7. PLATE
8. POST
9. SILL

ELEMENTS OF DEAD SHORING SYSTEM

10. NEEDLE BEAMS
11. POSTS
12. FOLDING WEDGES
13. SILL

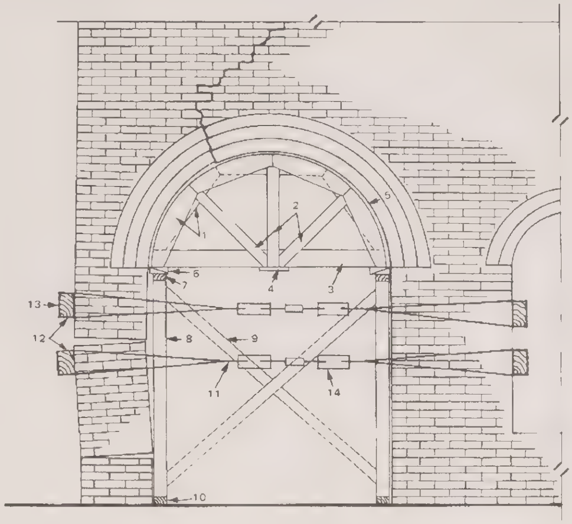
NOTE:

1. INSTALL DEAD SHORING, SHOWN IN DOTTED LINES FOR SAKE OF CLARITY
2. INSTALL CENTERING
3. REALIGN ARCH
4. MAKE COSMETIC REPAIRS
5. ALLOW REASONABLE TIME FOR NEW MORTAR TO SET BEFORE REMOVING DEAD SHORING
6. PROGRESSIVELY REMOVE CENTERING BY LOOSENING WEDGES UNTIL DOWNWARD MOVEMENT OF ARCH CEASES

ARCH SHORING SYSTEM FOR CASE OF OVERLOADING 1 OF 3

Figure 18

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING			N.T.S.
Parks Canada / Parcs Canada	SOURCE / RESOURCE: RESTORATION	CHECKED BY / VERIFIE PAR: G.E.S.	DATE / DATE: 1979
	DRAWN BY / DESSINE PAR: JAN SKLENAR	REFERENCE No. / No. DE REFERENCE: AOR0610A1	



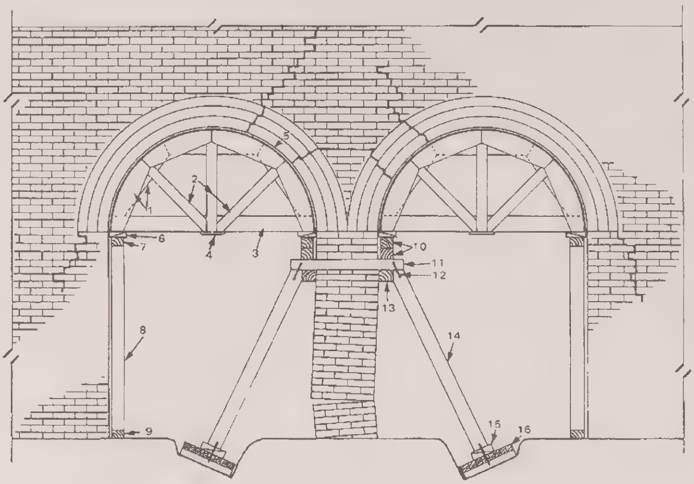
ELEMENTS OF CENTERING SYSTEM
1. 19mm PLYWOOD OFFSET TO INCREASE RIGIDITY
2. DIAGONALS 38 x 140 MIN.
3. BOTTOM CHORD 38x241 MIN.
4. LACING BETWEEN CENTERINGS
5. 10mm PLYWOOD SHELL
6. FOLDING WEDGES
7. PLATE
8. POST
9. BRACING BETWEENPOSTS
10. SILL

ELEMENTS OF TIE BRACING SYSTEM
11. 13mm φ STEEL CABLE
12. WALERS
13. 6mm STEEL PLATE
14. TURNBUCKLE

NOTE:
1. INSTALL DEAD SHORING SYSTEM, AS SHOWN IN DOTTED LINES IN FIG. 18
2. ERECT CENTERING.
3. INSTALL TIE BRACING.
4. REALIGN ARCH AND ABUTMENT.
5. MAKE COSMETIC REPAIRS.
6. ALLOW REASONABLE TIME FOR MORTAR TO SET BEFORE REMOVING DEAD SHORING AND TIE BRACING SYSTEMS.
7. PROGRESSIVELY REMOVE CENTERING BY LOOSENING WEDGES UNTIL DOWNWARD MOVEMENT OF ARCH CEASES.

ARCH SHORING SYSTEM FOR CASE OF ABUTMENT DISPLACEMENT *Figure 19*

TITLE / TITRE			SCALE / ECHELLE
SHORING AND BRACING			N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE RESTORATION	CHECKED BY / VERIFIE PAR G.E.S.	DATE / DATE 1979
	DRAWN BY / DESSINE PAR JAN SKLENAR	REFERENCE No. / No DE REFERENCE AOR061CA1	



ELEMENTS OF CENTERING SYSTEM

1. 19mm PLYWOOD OFFSET TO INCREASE RIGIDITY
2. DIAGONALS 38 x 140 MIN.
3. BOTTOM CHORD 38 x 241 MIN.
4. LACING BETWEEN CENTERING
5. 10mm PLYWOOD SHELL
6. FOLDING WEDGES
7. PLATE
8. POST
9. SILL

ELEMENTS OF RAKING SHORE SYSTEM

10. DOUBLE PLATE
11. BEAM
12. DOG(CRAMP)
13. WALL PIECE
14. RAKER
15. FOLDING WEDGES
16. TIMBER GRILLAGE

NOTE:

1. INSTALL DEAD SHORING SYSTEM AS SHOWN IN DOTTED LINES IN FIG. 18.
2. ERECT CENTERING AND RAKING SHORES
3. REALIGN ARCH AND ABUTMENT
4. MAKE COSMETIC REPAIRS
5. ALLOW REASONABLE TIME FOR MORTAR TO SET BEFORE REMOVING DEAD SHORING
6. PROGRESSIVELY REMOVE CENTERING AND RAKING SHORES BY LOOSENING WEDGES UNTIL DOWNWARD MOVEMENT OF ARCH CEASES

ARCH SHORING SYSTEM FOR CASE OF ABUTMENT SUBSIDENCE

Figure 20

TITLE / TITRE: SHORING AND BRACING			SCALE / ECHELLE: N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE: RESTORATION	CHECKED BY / VERIFIE PAR: G.E.S.	DATE / DATE: 1979
	DRAWN BY / DESSINE PAR: JAN SKLENAR	REFERENCE No. / No. DE REFERENCE: AOR0610A1	

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

3.3
INTERIM PROTECTION
ENVIRONMENTAL CONTROLS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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1.0 INTRODUCTION

This article briefly describes methods of interim protection for historic structures utilizing environmental controls. The objective is to stress the need for and ensure adequate remedial action to reduce the causes and effects of detrimental environmental factors. The Bibliography (4.0) is intended as a reference guide for detailed considerations.

Protection of historic structures should commence in the initial phases of the project. It is especially important for structures which may not receive complete attention for many years.

This article, with the bibliography, is intended for design staff who prepare interim protection plans for historic structures. It should be read in conjunction with the other publications in Vol. IV.3.

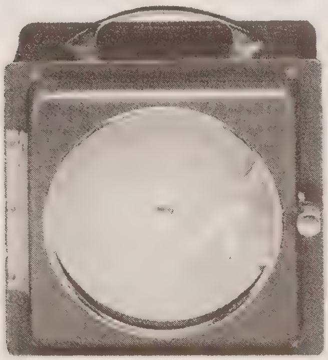
2.0 ENVIRONMENTAL CONTROL SYSTEM

In general, the interim protection of any historic structure involves counteracting elements of damage and decay; the specific means and extent is always determined by an actual situation and by the existing architectonic state and condition of the structure.

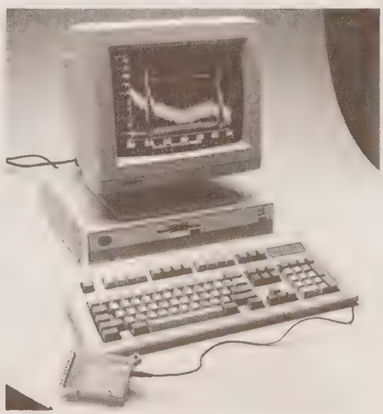
2.1 SYSTEMS TO CONTROL HUMIDITY

Relative humidity of the air can be measured by an air hygrometer or by a psychrometer. The most effective protection against the imbalance of outdoor and indoor vapour pressures is, simply, air ventilation. The relative humidity can vary in different seasons, and fluctuate at different rates, but in normal conditions it seldom rises above the level of 35 percent during the daytime and often decreases below 15 percent during this period. Early morning percentages, the highest each day, seldom exceed 60 percent. If and when the air circulation is inadequate, such situations will result in a moisture increase, dampness and fungus formation. "A sizable proportion of outbreaks of wet and dry rot are caused by condensation. If a building is left unoccupied, particularly in winter, local condensation of stagnant air when the termperature drops can produce suitable conditions for such fungal growth as moulds on walls and ceilings and dry rot in the structural timbers" (Feilden, p. 172).

It is equally important to maintain control over fungus growth generally, but always with the aim of trying to remove it either mechanically or chemically. A radical elimination of such fungus-infested areas by forceful drying up is not recommended; this should be done gradually and as a part of an overall interim protection program.



Basic Hydrometer



Temperature and Humidity Logger
Courtesy ACR Systems Inc.

2.2 SYSTEMS TO CONTROL TEMPERATURE

The temperature of the air is measured by thermometers or with special (electrical) thermal devices capable of rotating toward a certain portion of the face of the wall; also used are special optical and infra-red thermometers designed to measure the surface temperature in large spaces.

The temperature of the outdoor air is the result of annual and daily cycles. During an interim protection period, it is important for the structure to be adequately protected against the frost which can cause great damage. An acceptable optimal temperature is up to 5°C, under reasonably well-balanced air circulation.

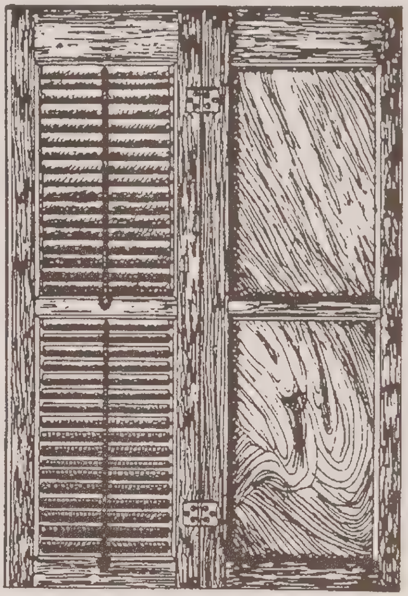
In case of serious damage caused to a ceiling or roof, it is important to repair the damage speedily. This should not be ignored because it will not only prevent further heat loss, but will also protect the structure against further negative influences of the weathering process. In some cases (for example, buildings of greater permeability), it may be desirable to install temporary insulation.

2.3 SYSTEMS TO CONTROL EXPOSURE TO SOLAR RADIATION

While solar radiation has positive effects (for example, moisture evaporation, natural light), it has also some damaging aspects such as unnecessary indoor overheating (the so-called "greenhouse effect"). Furthermore, it may upset the balance between the indoor and the outdoor temperatures and bring unwanted ultra-violet emissions so often responsible for permanent damage to the interior, the paint work and to other interior elements. In the interim, it is often sufficient to reduce the destructiveness of such radiation simply by partial shading of the windows and other openings or by creating some shade outside and around the building.

2.4 VENTILATION

Air circulation depends upon changes in the air pressure, which, in turn, is affected by the air temperature. Natural ventilation is relatively easy to achieve and is not too difficult to regulate by electrical or mechanical means. However, if over-ventilation occurs, there is a danger of a further damage caused by penetration of rain and snow or dust pollution. Effective ventilation can be achieved by horizontal air circulation. Vertical air circulation must always be in accordance with the fire hazard regulations for historic buildings. Protection of historic buildings against fire and the maintenance of proper ventilation are both important components of interim protection.



Temporary Ventilation

2.5 SYSTEMS TO CONTROL MOISTURE

There are several different types of methods and techniques used for drying out moisture in historic structures. These are divided into three main categories:

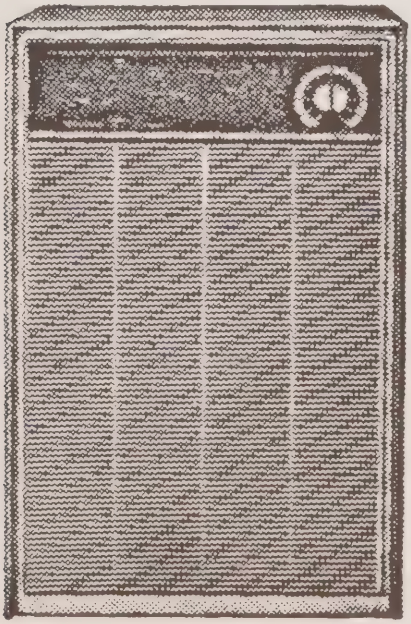
a. methods based on stimulating the ventilation of walls affected by humidity;
b. methods based on electrochemical dehumidification; and
c. methods based on the introduction of insulation and water proofing.

The problem of moisture and its elimination has been most extensively covered in conservation literature. Specific techniques and the best methods to apply will be determined in each particular case.

In some cases, when it has been determined that the building walls are over-saturated with moisture and there is visible damage, then it is advisable to erect a temporary support structure to stay in place until a more permanent structural solution is implemented.

2.6 SYSTEMS TO CONTROL BIOLOGICAL COMPONENTS

Nearly all of the biological components causing decay are removable. Trees, bushes and other vegetation threatening the building environment can be removed if they are of no historical significance; otherwise they can be cut back and kept pruned. Structures affected by bird excrement can be treated chemically and further damage can be prevented by installing special barriers.The most dangerous of all the biological components is careless human intervention, against which there is no prevention other than reduced accessibility.



Dehumidifier

3.0 CONCLUSION

Interim protection is dependent upon the condition of the structure, the available financial and human resources and the anticipated development date.

Environmental controls provide an essential part of the interim protection design scheme and should be studied and implemented in combination with other architectural and engineering work.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

3.4

INTERIM PROTECTION

HISTORIC GARDENS AND LANDSCAPES

PRODUCED BY:
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1.0 INTRODUCTION

When a historic landscape or garden has been identified for preservation, it is necessary to undertake steps to ensure ongoing protection of the site and all its elements through the course of development. With requirements for research, archaeology, design and development, the process can take a number of years. Between the time the site is acquired and its opening as a historic site there is a need to ensure that the physical features are not damaged or allowed to deteriorate.

Interim protection involves the application of techniques and designs to provide temporary consolidation while awaiting long-term preservation, rehabilitation or restoration. With a landscape it is impossible to adapt a blanket policy of mothballing and vandal-proofing. More suitable for historic structures than gardens and landscapes, these measures can result in deterioration and loss of historic fabric. Furthermore, the research and analysis phases of the conservation program can, in themselves, pose serious threats to the historic fabric. Archaeological excavations can seriously disrupt the landscape and destroy superficial traces of gardens and other site features. Protection and remedial care to historic buildings can also contribute to the demise of gardens and landscapes. Foundation work, for example, can cause the wholesale destruction of existing grades, plant material and walkways around the perimeter of a structure.

Province House, Charlottetown, PE

Even the application of standard housekeeping procedures to care for a historic garden or landscape can inadvertently cause destruction when not properly supervised and when maintenance personnel are not adequately trained. Specifications for protection of the historic garden and landscape features should be included in all tender documents for maintenance work as well as for contractors who may be excavating or otherwise causing damage to grades and landscape features. Protection clauses should also be a part of any authorization for archaeology, recording and building stabilization.

1.1 HARD AND SOFT LANDSCAPE COMPONENTS

For the purposes of discussing interim protection, historic gardens and landscapes can be considered as consisting of components which are classified as hard landscape or soft landscape.

Upper Canada Village, ON

Hard landscape includes those components of the site which are basically inert and which can survive with minimal periodic inspections and with suitable protection from fire and vandalism. These include such items as walks, fences and other ancillary structures.

Soft landscape components are organic in nature and require periodic care (either seasonal or at regular intervals) such as grass-cutting and weeding. Interim protection should be considered as a landscape maintenance program for soft landscapes.

Interim protection assumes that the site is being actively investigated, research is underway and the design and development phases are scheduled. Interim protection of a site under development should differ in the level of maintenance and the commitment of funds from a site which is "mothballed."

A landscape requires ongoing supervision. It is important that periodic inspections be established. These include a walk around the site at least twice a year and preferably four times, once each season. The objective of such a tour is to ensure that problems or deterioration of site features are noted and necessary remedial action recommended. As well as periodic inspections and the cyclical maintenance common to any site, there is also a need to establish a housekeeping maintenance program to ensure the continued survival of the soft landscape features.

2.0 COMPONENTS

2.1 LAND PATTERNS

This component deals with the broad planning issues; the predominant land forms such as waterways, hills, ridges and vast prairie; and the land-use activities which were imposed and which occupy and incorporate the landform. Often these large-scale features give the built components their reason for existing.

The protection of these large-scale features falls into the jurisdiction of the planning process. The immediate features are protected through acquisition. At small sites it is frequently necesssary to preserve the physical environment surrounding the acquired site by introducing conservation legislation, height restrictions, zoning bylaws or other land-use controls. This process requires close co-operation with local authorities, public agencies, property owners, occupants and other members of the community.

The activities of rezoning and establishing restrictive development covenants are frequently practised in urban areas. Historic landscapes and gardens in rural settings are increasingly being threatened with development pressures which would dramatically change the site's character and which also need some type of control or regulation.

Natural features, such as mountains, and material components, such as roads, field systems or urban streetscapes, should be recognized as essential components of the landscape. Steps should be taken in the interim to protect their relationships prior to the development planning.

2.2 CIRCULATION NETWORK

The roads and paths of a historic landscape or garden form part of the hard landscape. Once they have been recorded and their location plotted on site survey drawings they will require very little attention for protection purposes. Unless roadways and drives are to be used to support heavy machinery or if they include grass paths or are used by large groups of people, interim protection can be limited to periodic inspection for safety and security purposes.

Usually only walkways and roads which are being regularly used should be cleared of snow. It is recommended that salt not be used because of the damage that it does to both the period buildings and the landscape elements.

When archaeology, involving excavation through roads or paths is being carried out, profile drawings are made as a standard procedure. Site utilities or services often follow a driveway or road system when they are being brought onto the site. Profile drawings should be made when additional excavation is required for underground services. Even temporary utility poles have an impact on the history and aesthetics of the site.

Prior to a site's development, care should be taken to utilize traditional paving materials and to preserve the extant dimensions of roadways if it is necessary to grade or top-dress the circulation routes.

2.3 BOUNDARIES AND ENCLOSURES

Boundaries and enclosures are important in that they provide the physical definition for the site, delineate the use areas and provide a degree of protection for the property.

Existing fences and boundary demarcations should not be removed until full recording has been carried out. The recording should include materials, construction techniques, vegetation, conditión and plotting.

L'Anse aux Meadows, NF

As part of interim protection, look at circulation routes and enclosures in order to establish clear means of entry and egress for construction vehicles and personnel during development. Areas for material storage, temporary structures and utilities should be designated. Protect sensitive areas and plant material with temporary fencing.

2.4 SITE ARRANGEMENT

The site arrangement is the internal placement of elements within a discrete landscape setting, including elements such as plant material, fences, paths and buildings. In order to ensure protection of the site, record these elements as a first step. A site plan should be prepared designating use areas, storage, access and zones to be preserved. Snow fencing is one method of providing appropriate protection for trees and shrubs. (See Parks Canada Technical Services, Environmental Design, Graphics Standards for appropriate installation of protective fencing around existing vegetation.)

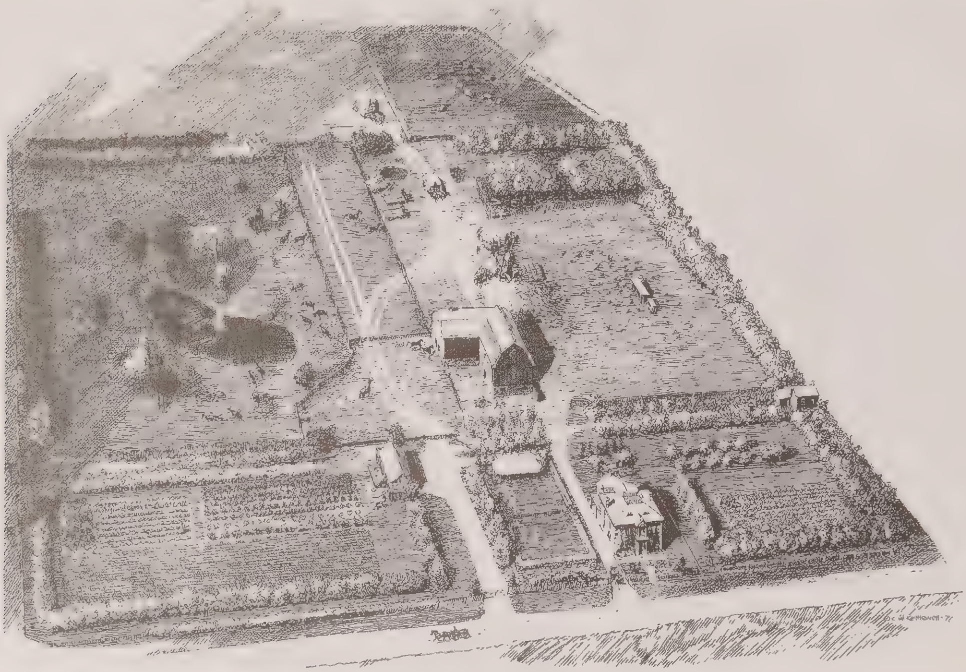
2.5 VIEWS AND OTHER PERCEPTUAL QUALITIES

This element is not as clearly defined as other components. Where views, vistas and other visually perceptual qualities have been identified, their protection should be ensured. Distant views and features not specifically a part of the site can be protected through land-use controls (see 2.1 above).

Care should be taken to prevent the addition of vegetation or structures onto a landscape until the visual aspects of the site have been analyzed.

2.6 GRADES AND TOPOGRAPHIC FEATURES

Site contours or grades should not require any special attention as a part of interim protection. There are exceptions to this, such as where erosion or slumping threatens to damage the site. In these cases, there should be records kept of the rate and degree of damage. Carry out studies to determine causes and remedial action to reduce the erosion or likelihood of slump.



Motherwell Homestead, SK

Erosion and wave action can result in damage to a shoreline and to landscape components on the shore such as docks or archaeological features. It is important that a system of periodic inspection and reporting be established as a part of a protection program. When damage is noted, the repairs are usually less extensive if action is taken at once than if the feature is left to deteriorate. It is important with water features that inspections be carried out to correspond with annual freeze-thaw cycles of fall and spring. The risk of damage is greatest during these two times of the year.

2.7 WATER FEATURES

Water features include everything from mill ponds to pumps and ornamental foundations. On an interim protection basis, the emphasis should be on ensuring that functioning items (for example pumps, fountains and irrigation systems) are maintained in good order. Water lines must be turned off and properly drained before annual freeze-up. Potable ground water should be periodically tested to ensure its quality.

Cape Spear, NF

2.8 STRUCTURES AND ACCESSORIES

For the most part, ancillary structures and accessories can be retained through periodic inspection and repair work as required. Appropriate treatment normally requires expertise by persons knowledgeable in historic resource conservation. Care should be taken not to destroy vestiges of site accessories during site cleanup. Remnants of fences or garden structures are often set aside or reused in another context. Unless they are identified and recorded, the historical information could be lost. See also Section 3.2 "Interim Protection: Stabilization of Historic Structures."

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.1

STABILIZATION

MASONRY STRUCTURES: CLEANING

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ORIGINAL DRAFT: GOUHAR SIMISON

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1.0 INTRODUCTION

The cleaning of historic masonry material is a complex process that demands an understanding of the nature of dirt and the causes of dirt accumulation. Cleaning agents and methods are numerous and include water, chemical, mechanical and laser methods. Every case is different and should be considered individually. This publication discusses various masonry cleaning agents and methods, their application, suitability, advantages and disadvantages. It is intended to be used as a reference source when designing a program for cleaning historic masonry surfaces and should be read in conjunction with Vol. VI.2.2 "Deterioration: Surface Deposits and Decay."

2.0 REASONS FOR CLEANING MASONRY

Analysis of surface deposits, stains or decay (see Vol. VI.2.2), together with a study of the masonry structure, its environment and the available cleaning methods, may reveal that cleaning is either unnecessary or undesirable.

Masonry material is cleaned to:

a. prevent future deterioration (when surface alterations prove to be unstable, causing continuous harm to the masonry surface);
b. restore original appearance of masonry (to reveal the original colours, textures and finish; and
c. cosmetically improve (to improve the psychological impact of the material in its environment).

3.0 CONSIDERATIONS WHEN CLEANING MASONRY

3.1 GENERAL FACTORS

The following points should be considered before a decision is made to clean a structure.

a. The dirt on the masonry surface may be part of the surface (such as the protective crust formed by weathering of the masonry or the patina which is protective, harmless and aesthetically desirable). Removing this layer would mean removing part of the masonry surface (see Vol. VI.2.2), making it more vulnerable to harmful dirt and pollution.
b. The cleaning method should not permit accelerated deterioration of the masonry surface by the polluting agents that orignally soiled it.
c. Masonry materials that appear to be similar may be geologically and chemically different. Materials should be identified and analysed professionally before cleaning. An acceptable cleaning method for one material may harm another.
d. Different cleaning methods and combinations of these methods should be tried and monitored on sample areas before being applied to the rest of the masonry structure.

3.2 APPROPRIATE LEVEL OF CLEANLINESS

Deposits and stains are acceptable when they do not cause mechanical, structural or aesthetic degradation and when they provide some surface protection.

Dirt that causes mechanical, structural or aesthetic degradation, however, should be considered harmful (see Vol. VI.2.2). Dirt should be removed by a suitable cleaning method that does not harm the masonry material underneath.

4.0 WATER CLEANING

Water cleaning methods include:

- Low-pressure wash
- Moderate to high-pressure wash
- Steam cleaning.

Water cleaning methods, in general, cause masonry material to absorb water. The time needed for each material to become wetted thoroughly varies greatly. Bricks absorb three times as much water as limestone or sandstone. The core and the surface become wet rapidly. However, in bricks, the water evaporates with equal rapidity. Sedimentary stones, however, retain much of the water absorbed during treatment. This can cause dampness on the inside walls, resulting in efflorescences, discolouration and plaster exfoliation.

Water Cleaning

4.1 LOW, MODERATE AND HIGH-PRESSURE WASH

The first two categories of water cleaning methods have many modes of application including:

a. Spraying from a series of fine nozzles moved up and down against the wall for 1-3 days;
b. Applying water jets with a differential pressure of at least 400 kPa (moderate to high pressure) for 4 hours to 3 days. This can be used effectively to clean polished surfaces without pre-soaking; or
c. Running a punctured hose along the top of the walls for about a week to spray, soak and clean the dirt from the masonry surface.

Soaking can also be accomplished by setting up several low pressure (and low volume) spraying devices, each with a wide angle of coverage.

> When the softening action is complete, dirt can be removed with a moderate-pressure (200 – 600 psi) wash-down at a convenient flow rate of about 4 gallons/minute. (Weiss, 1975, p.6)

Pressures of 4.9 mPa – 5.5 mPa can be safely used on very hard surfaces. Softer or decayed surfaces will severely deteriorate under high-pressure water cleaning, similar to severe abrasion caused by abrasive blasting.

The application of water as mentioned above, removes water-soluble constituents of the dirt and the remainder swells and can be brushed off with bristle brushes.

Textured masonry requires a considerable amount of brushing, especially if the dirt contains hydrophobic organic material.

A suitable combination of spraying, brushing and/or rinsing can be determined by experimenting on sample areas of each type of masonry material.

Porous masonry may absorb excess amounts of water during the cleaning process, causing damage within the walls or on the interior surface (see Vol. VI.2.2). For this reason all joints, including mortar and sealants must be sound in order to minimize water penetration to the interior. Normally, however, water penetrates only part way through even moderately absorbent masonry materials.

Water cleaning is an important adjunct to many chemical cleaning processes. It can sometimes be used to clean efflorescents. Warm water is recommended for saltpetre efflorescents and cold water for sodium sulphate efflorescents.

a. Advantages:
   - versatile as a sensitive cleaner for old masonry
   - readily available
   - application is simple
   - materials and equipment are inexpensive
   - safe for health and environment.

b. Disadvantages:
   - danger of damage resulting from excess water penetration, especially in porous stone. This can bring soluble salt from within the masonry to the surface

- possibility of damage to interior woodwork, plaster and points
- possible weakening of the masonry material, especially because the mechanical strength in most porous materials decreases when wet
- time consuming when scrubbing by hand is necessary.

CAUTIONS: Climatic conditions must be considered. Water cleaning should not be done during freezing conditions, because of the risk of freeze-thaw damage.

Limestone and marble (carbonate rocks) are more easily dissolved by the mildly acidic water supplied by most public water systems than are siliceous masonry materials. For this reason, it is often suggested that extremely lengthy washing procedures be avoided.

Staining can result from some applications:

> In the case of lighter-coloured limestones and marbles, it is notoriously difficult to achieve a uniform appearance with washing. A mottled brown staining is often observed, probably due to the reappearance of small amounts of water-soluble material upon evaporation of deeply imbibed water. This situation is difficult to correct; further rinsing is sometimes partially effective. The appearance of iron and copper stains, a possibility in regions in which the local water supply has a relatively high heavy metal content, is more easily avoided with the introduction of complexing agents into the wash water. (Weiss, 1975, p. 7)

The use of "hard" water limits the dissolving action of water treatments.

4.2 STEAM CLEANING

Steam cleaning combines the dissolving action of water with the advantages of high temperature.

> Steam is generated in a boiler and is directed to the stone surface via a pipe and a nozzle of 1-1.6 cm in diameter. The steam pressure is 68 kg/cm^2 [7 mPa] (for old stone) and about 56 kg/cm^2 [5 mPa] (for new stone). Condensation of steam on the pipe interior, friction and expansion after emerging from the jet reduces the pressure of the steam so that it is not more than 0.5 kg/cm^2 [50 kPa differential pressure] at the point of contact with the stone. (Stambolov and van Asperen de Boer, 1976)

Others recommend a pressure at the nozzle of 150-200 kPa with a duration of treatment of 6-10 minutes per m^2.

An average working time of 1000 cm^2/minute seems to be required for adequate dirt removal. The high temperature of the steam and the condensed water swell the dirt deposits, so that even a low-pressure steam jet can sucessfully clean the loosened material from the surface. It is very often necessary, however, to supplement the steam cleaning with brushing.

Stone surfaces other than limestone may require a combination of chemical and steam cleaning. First, the chemical should be applied to soften the grime, then steam cleaning should follow. A mixture containing complex phosphates ($Na_6P_6O_{16}$, $Na_4P_2O_7$, $Na_5P_3O_{10}$), potassium-silicate and some anionic soap can be used as a medium for dirt-softening. Diluted phosphoric acid (5 percent in water) may also be used, but caustic soda causes efflorescence and should be avoided.

Steam cleaning of marble can be effective if marble is first covered with a slurry of an alkaline cleaner for about 15 minutes before being steam cleaned. A thorough rinsing of cleaner and dirt must follow.

a. Advantages:
   - one of few methods currently available for removing dirt from very irregular surfaces without causing mechanical damage
   - steam-cleaned brickwork does not develop whitish or greyish bloom, nor is there any disturbance of the mortar joints
   - likelihood of staining after cleaning is less than with water washing. This makes steam cleaning useful sometimes as a follow-up to other cleaning procedures.

b. Disadvantages:
   - imparts an unnatural appearance to some marbles and afterwards they may be more easily polluted
   - safety hazards to the operator may be substantial
   - expense is greater than with other water cleaning methods
   - if application of chemical cleaners is necessary, there is little justification for the steam method, considering the additional expenses of the equipment.

5.0 CHEMICAL CLEANING

Chemical cleaners fall into the following general categories:

- acidic cleaners
- alkaline cleaners
- surfactants (surface-active-agents)
- organic cleaners
- poultices.

Chemical Cleaning

5.1 GENERAL METHOD FOR USING CHEMICAL CLEANING SOLUTIONS

The masonry should be pre-wetted to soften the dirt and to help diminish the amount of cleaning solution and dirty rinse-water, which may otherwise be absorbed by the masonry and mortar.

The chosen chemical solution should be prepared in as weak a concentration as practicable and applied with brushes or a low-pressure spraying system.

The cleaning agent is allowed to remain on the masonry according to the prescription provided with the chemical material, then rinsed with water using a moderate-to-high-pressure water spray working from the top to the bottom of the masonry walls.

5.2 ACIDIC CLEANERS

Hydrofluoric (HF) and phosphoric acids (H_3PO_4) are the major compounds of acidic cleaners. Acidic products are used mostly in cleaning granites, sandstones and unglazed brick. However, they may penetrate deeply into sandstone and be retained for years.

Acidic products tend to dissolve limestone and should be avoided on rocks containing carbonates. Pre-wetting masonry surfaces is recommended with both acidic and alkaline products to soften the dirt and minimize absorption of the cleaning agent and rinse water.

5.2.1 Hydrofluoric Acid (HF)

Hydrofluoric acid has been used in cleaning stone covered with soot, silica and gypsum. It should be used in concentrations up to 5 percent by volume. It dissolves redeposited silica, silica dust (in contact with the masonry surface) and a minute amount of the masonry surface itself, thus loosening the accumulated dirt.

a. Method:

- masonry is wetted and kept moist during the cleaning process to avoid silica deposition
- an HF solution of 3-5 percent is prepared, to which a small amount of phosphoric acid is added
- the chemical solution is applied (with brushes or with a low-pressure spraying system) and allowed to remain on the masonry surface for several minutes to maximize efficiency
- the chemical cleaner is then rinsed with water.

b. Advantages:

- reaction of HF with siliceous stones and brick produces silicon tetrafluoride (SiF_4) which is a gas at ordinary temperatures and keeps harmful residual material to a minimum.

c. Disadvantages:

- HF has an etching effect on glazed or polished surfaces
- all acidic products can be harmful when used on carbonate rocks (limestone and marble) and on calcareous sandstones which contain calcium carbonate.

CAUTIONS: HF causes discolouration of some stone materials because of the reaction with the brown iron compounds forming the colourless iron fluorides. Sometimes this acid forms whitish deposits of amorphous silica on brick and siliceous stones. This deposit is chemically stable, but can be unattractive on darker masonry. The same deposit is soluble in HF, however and can be removed by a second treatment followed quickly by a thorough water rinse. A small amount of phosphoric acid is usually added to the hydrofluoric cleaning solution to prevent the development of the rust-like stains.

5.2.2 Phosphoric Acid (H_3PO_4)

Phosphoric acid may be used as an additive to other solutions to prevent discolouration. See 5.2.1.

5.2.3 Hydrochloric Acid (Muriatic Acid or HC1)

This acid is an inefficient cleaner and can leave hygroscopic chlorides behind, leading to serious damage of masonry surfaces. Therefore, it is not recommended for general use on historic masonry.

Some commercial acidic cleaners contain primarily chlorides (Cl^-) and have pH values as low as 2.8.

5.3 ALKALINE CLEANERS

Alkaline cleaners are useful in treating materials that are acid-sensitive, especially in the case of limestones and marbles.

Some commercial alkaline cleaners contain primarily phosphates (PO_4) and have pH values as high as 12.8.

5.3.1 Sodium Hydroxide (NaOH)

Many alkaline cleaners are formulations based on NaOH (caustic soda). These may cause efflorescence and subflorescence to appear on older masonry material; therefore they are not recommended for general use on inorganic building materials.

5.3.2 Ammonium Hydroxide (NH_4OH)

This agent is also called "ammonia" and is suitable for use on historic masonry.

5.3.3 Ammonium Bifluoride (NH_4HF_2)

This agent is used as an "all purpose" cleaner. However, it may prove to be no more suitable for cleaning calcareous masonry than other cleaners. It can cause the formation of ammonium salts.

5.3.4 Sodium Hydrogen Citrate ($NaC_6O_7H_7$)

This agent is used in solution with water and a small amount of glycerine to remove stains or efflorescence of iron compounds (that have no defined periphery on stone) by applying cotton-wool pads soaked in this 15 percent solution. "The pads are pressed down with glass plates (to hinder a rapid evaporation) and upon these plates are placed weights to promote better contact between stains and cotton-wool fibres." The glycerine keeps the pad damp for a longer time. "Every 3 – 4 days, the pads are soaked again and the treatment is repeated until a satisfactory removal of the stains is achieved." (Stambolov and van Asperen de Boer, 1976)

5.4 SURFACTANTS (SURFACE-ACTIVE-AGENTS)

Surfactants' molecular characteristics cause them to react with and loosen dirt. One end of the molecule is attracted to the dirt, the other end is attracted to the water. Thus the dirt becomes suspended in the water.

Surfactants can be acidic or alkaline organic compounds which are soluble in oil or water. They have cleaning and wetting power. They can be classified as: anionic, cationic and non-ionic.

5.4.1 Anionic Surfactants

Anionic surfactants may react with limestone or dolomite to form insoluble calcium and magnesium soaps which solidify the dirt rather than help remove it.

5.4.2 Cationic Surfactants

Cationic surfactants do not contribute to the removal of dirt from stone and ceramics and moist inorganic building materials are usually negatively charged and so they readily absorb this kind of surfactant.

5.4.3 *Non-ionic Surfactants*

Non-ionic surfactants have none of the disadvantages of the anionic and cationic surfactants and they have a greater wetting capacity.

The chemical composition of all surfactants determines their power as a cleaning or wetting agent. Likewise, the choice of a surfactant depends on the nature of the dirt and the masonry material. According to Stambolov and van Asperen de Boer:

- "hexametaphosphate is effective in removing carbon deposits
- alkylbenzenesulfonate is good for cleaning stone in general
- dimethylamylbenzylammonium is effective in removing dirt on limestone"
- ethoxylated alkylphenols and ethoxylated alcohols (non-ionic) are useful for most masonry surfaces in concentrations of 1-2 percent (weight/volume).

Some surfactants have foaming properties when applied by a spraying system. The thick lather increases cleaning efficiency by keeping the active chemical cleaner in contact with the masonry for a longer time.

Surfactants alone can be used safely on polished granites and on glazed brick without the risk of etching.

5.5 ORGANIC CLEANERS

Dirt consisting of grease and water-soluble matter is probably best cleaned with organic solvent/water emulsions. In removing oil and grease from masonry, the surface tension of the liquid-displacing agent must be lower than the surface tension of the oil to be displaced (the greater the difference in surface tension the better the cleaning). The displacing agent must also be sufficiently soluble in the oil or grease.

Appropriate cleaning compounds and techniques are described for various types of dirt by Stambolov and van Asperen de Boer and others in available technical literature (see Bibliography). Special formulations have been developed for situations such as obstinate greasy residues, oil stains on marble and stains of organic origin.

5.6 POULTICE TECHNIQUES

The poultice technique is described by Stambolov and Van Asperen de Boer as follows:

> ... chemicals are mixed with water and an absorbent powder into a paste which absorbs the dirt after application. Absorbent powders should have a very large specific surface and a fine porous structure. Starch, chalk, talc (talcum), corn meal, flour, magnesia or magensium silicate are common absorbent powders. The water solution of the chemicals used for cleaning are either acid or alkaline and the pastes made with them are normally applied as a 3 mm thick layer on the surface to be cleaned. The concentration of the chemical should be mild rather than strong and cleaning should be done gradually.

The paste technique allows minimum penetration of water into the cleaned material. Various poultice techniques are described by Stambolov and van Asperen de Boer and others (see Bibliography), involving situations such as stains of iron compounds and rust, copper stains and grease stains on marble.

Rag fibre poultices are used with water alone for removal of water soluble salts.

6.0 MECHANICAL CLEANING

Mechanical cleaning includes grit blasting, grinding with rotary wheels and sanding with power-driven carbide cones and discs. Belt sanders, rotary wire brushes and blasting machines are common tools for mechanical cleaning. This method of cleaning abrades the dirt from the masonry surface rather than reacting with it. Thus erosion of the masonry surface is inevitable as abrasives do not differentiate between the dirt and the masonry. Abrading methods should not be used on brick, soft stone, carvings or polished surfaces, where even minimal erosion is unacceptable.

Wire brushes may stain because of metal bits left on the masonry. Therefore natural bristle brushes and wood scrapers should be used. Consideration should be given to the potential harm to other building materials associated with masonry, such as mortar joint and wood elements.

Results of Mechanical Cleaning

6.1 SANDBLASTING

Sandblasting erodes the mortar joints of masonry and causes damage through loss of joint details. It also can cause structural damage, by permitting increased water penetration. In the latter case, complete repointing after cleaning becomes a necessity. The effects of sand blasting on joints are considered significant, as joints can constitute large portions of masonry surface (up to 20 percent in brick walls).

Sandblasting causes the removal of the patina and of the original texture of the masonry surface. This practice is not acceptable where preservation of the historic structure is being attempted.

If sandblasting in a particular situation is the only reasonable alternative, the use of iron-free sea sand is recommended to avoid rust stains. The pressure at the nozzle of the hose should not exceed 270 kPa and should be kept at least 7 cm from the masonry. This method can be harmful, however, even when carried out with the utmost caution.

> Typical operating conditions for both wet and dry abrasive blasting are in the range of 20 to 100 psi (measured at the nozzle) with a working distance of 3 – 12 inches. Nozzle sizes vary, but the most common size is that having a $^1/_4$ inch aperture. Only a few nozzles are available that permit the operator to directly control the pressure. In most instances this is pre-set at the compressor and the operator will vary the working distance to suit observable variations in dirtiness and hardness of the surface. (Weiss, 1979, p. 15)

6.2 ·WET BLASTING

Wet blasting is slower than the dry method. The addition of water to abrasive blasting is useful, primarily in softening the dirt. In addition, it eliminates dust, which can be a significant health hazard. However, the wet grit accumulates as a messy slurry on the ground. Cautions similar to those for water cleaning should be observed when using this method (see 4.0).

Results of wet and dry abrasive cleaning are usually comparable. A major disadvantage of the wet grit blasting is that it needs more care and time.

> Many contractors and operators find the wet method troublesome; clogging of the nozzle can be a frequent problem, requiring the periodic shutting down of the apparatus for cleaning. In addition, most wet machines require that the abrasive be introduced at the gun. When the work is being done from a staging platform, buckets of the abrasive material must be hauled up to the operator. (Weiss, 1975, p. 14)

Wet blasting is used in specific controlled situations, for cleaning limestone, sandstone, mortar, bricks and metals. The pressure of the water jet is from 100-300 kPa at a distance of 30 cm from the wall. A 0.2-0.6 mm thick layer can be removed after 15 seconds. Masonry surfaces will erode according to their hardness.

7.0 OPTICAL RADIATION

Optical radiation cleaning techniques promise new solutions to many of the problems associated with chemical and mechanical treatment of masonry. Pulsed laser radiation and high-intensity flashlamp radiation are the two techniques currently being developed.

7.1 LASER

In the art conservation field, laser implementation dates back to the beginning of the 1970s when research revealed that surface divestment and cleaning lend themselves to laser treatment.

> While the several thousand different types of devices known generically as lasers can differ greatly in size, composition, appearance, function, and performance, they have one thing in common: the process of stimulated emission. In other words, the breakthrough in developing the laser was not simply the invention of a particular device, but rather the discovery of a process for controlling light. And this process is one that affords control in several directions – wavelength selectivity (through the infrared, visible, ultraviolet, and X-ray range), intensity, directivity, temporal duration, and coherence. (Asmus, p. 14)

Extensive tests were conducted in 1973-75 at the University of California, San Diego, to explore the applications of laser-induced divestment in art conservation. It was found that laser cleaning may be accomplished by means of several interaction mechanisms, such as superficial evaporation, vapour blasting, thermal and photodecomposition, differential thermal expansion and shockwaves.

> First, there is the obvious possibility of superficial evaporation of substances. Second, if the heating is sufficiently rapid, the expanding vapors are able to scour the nearby areas much like blast cleaning (as with water or air). A variation of this involves moistening the surface with water prior to irradiation and inducing a localized steam cleaning. Third, very low laser energy fluxes are able to break down superficial layers through thermal and photodecomposition. The debris is then easily washed away. Fourth, intermediate rate heating of a few substances will induce differential thermal expansion which leads to delamination of superficial deposits. Finally, when the laser pulse is exceedingly brief (e.g. 10^{-8} sec), a shockwave is generated and spallation phenomena will remove material down to a specific depth or to a bonding plane.
>
> Through adjustments in the laser's color, pulse length and energy, together with control of the cover fluid (air, argon, carbon dioxide, nitrogen, water or freon) and beam convergence, it often is possible to emphasize only one of the above interactions. Thus in a sense the laser may be "tuned" to produce a specific result. (Asmus, p. 16)

Surface divestment with light will probably become more important when more versatile laser types become commercially available.

Existing laser types can be practical in cases where the only alternative in cleaning large areas is by slow and costly manual techniques. In addition, lasers provide a non-destructive method of handling very delicate and fragile areas, because it is a non-contact procedure which avoids the use of any solvents or chemicals which may have harmful effects.

A laser can be directed over a large distance in order to reach areas of ceilings and walls which otherwise are accessible only with scaffolding and climbing.

Potential advantages:

a. may be tuned to interact with different kinds of masonry and can be easily automated
b. represents reduced use of chemicals and solvents that contribute to environmental pollution
c. photons (light particles) in the laser safely clean the irregular profile of masonry materials, as they do not distinguish between peaks and valleys of the surface
d. can remove any undesired layer with suitable optical flux intensities
e. non-contact localized control of surface divestment is a major advantage. A laser directed over a large distance cleans only where directed and removes the specific thickness of the material, with no physical contact to the material being cleaned.

Disadvantages:

a. relatively high cost limits their use to small objects or areas
b. lack of reliable operators who are scientifically trained
c. "unknown" factors in this relatively new field of cleaning.

7.2 FLASHLAMP

Flashlamp radiates a rich ultraviolet light that is used for surface divestment of historic materials. A number of special problems in surface cleaning can be solved where present laser and flashlamp technologies are able to complement each other in one cleaning method. Flashlamp systems circumvent many of the limitations of current lasers, however, they are only suitable when surfaces to be cleaned are relatively flat.

Advantages:

a. though expensive compared to other cleaning methods, is much cheaper than the laser system
b. covers much larger areas than laser beams
c. does not contribute to environmental pollution
d. a non-contact cleaning approach.

Disadvantages:

a. compared to laser, can only be directed over smaller distances
b. relatively expensive.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.1.1

STABILIZATION

MASONRY STRUCTURES: REINFORCEMENT

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
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ORIGINAL DRAFT: P. STUMES

CONTENTS

1.0 INTRODUCTION

This publication describes methods to repair and strengthen weakened masonry structures.

It deals with reinforcement, to the extent of re-establishing the original load-bearing capacity. This is done by applying methods and adding materials which are compatible with the original fabric. New work is kept to a minimum. The more extensive introduction of new beams, posts and other structural elements to significantly upgrade a building are dealt with in Section 5.3 "Rehabilitation: Structural Modifications."

It is a complex operation which should be attempted only by qualified professionals, following extensive testing. This publication describes a variety of methods for reinforcement to provide background for responsible staff involved in recommending suitable approaches for a given condition. The selection of particular methods and materials must be made in close consultation with qualified conservation experts.

1.1 RELATED INFORMATION

Occasionally, it may be necessary to dismantle and rebuild badly deteriorated masonry structures. Such action is outside the scope of this publication.

This article is limited to consideration of structures built of unit masonry, particularly brick and stone.

2.0 REINFORCEMENT

2.1 PRELIMINARY WORK

Reinforcement or consolidation becomes necessary whenever structural failure is evident or potential. While regular maintenance of a building is carried out, ensure that on-site inspectors watch for signs of potential failures, such as cracks, sagging elements, bulging, leaning or misalignment. Regular inspection of structures can predict the need for consolidation or reinforcement and prevent structural problems from endangering the historic resource and the public.

If symptoms of potential failure appear, ensure that the structure is closely examined by qualified professionals.

Certain anomalies do not necessarily cause failures or diminish the load-bearing capacity of a structure. Sometimes bulging walls or sagging floors may have continued to carry their loads for many years without any further problems and would continue for many more years. These elements may be found stable by the examining professional. No corrective action would then be required as the condition can be considered to be the historical development or evolution of the structure. When thorough analysis of the structure reveals the causes of failures, good practice dictates that these causes must be eliminated prior to attempting the consolidation or reinforcement of the structure. It must be clearly understood by managers establishing funds and time-frame schedules, that when a structural element is stabilized, but the causes of failure are not corrected, the forces which caused the failure will act again. In such cases it is probable that deterioration will occur again, if not at the stabilized section then at some other location.

2.2 INTERIM STRUCTURAL STABILIZATION

If required and recommended by examining professionals, interim structural stabilization should be implemented until the long-term stabilization is carried out.

2.2.1 Scaffolding

Consolidating and reinforcing work usually requires special means of access to the portion of the structure to be repaired. If structural elements are faulty, it is advisable not to use them as a platform for carrying out the work. When appropriate, erect scaffoldings independent from the faulty structure, to adequately support the workers and their equipment. Scaffoldings must be designed and erected according to established standards by qualified personnel.

2.3 REALIGNMENT

After the causes of failures are treated, but before commencing consolidation or reinforcement work, the structural elements should be realigned when necessary to maintain structural integrity. Realignment represents the correction of the following conditions:

a. sagging arches repositioned with the help of appropriate centring and form work; and
b. gaps or cracks, bulging, leaning or sagging parts encouraged to return to the correct position.

It is necessary to re-emphasize that realignment should be attempted only as a last resort to:

a. maintain the structural integrity and capacity;
b. protect the building's internal environment;
c. protect the architectural or artistic features; or
d. re-establish the visual integrity.

Do not attempt to realign the structure if it:

a. endangers the stability of the structure;
b. falsifies the historic appearance of the structure; or
c. requires an irreversible intervention, for example the installation of contemporary supports leaving permanent marks.

Realignment should be undertaken very cautiously as masonry response and behaviour is difficult to predict.

Temporary Bracing
St. Andrews Church on the Red, St. Andrews, MB

2.3.1 Methods

Exercise extreme care when realignment is attempted, to avoid damaging the exterior features of the building. Various devices, such as jacks, may leave marks on the historic fabric. Place properly designed padding between historic masonry and the equipment to prevent markings.

A complete description of the design and operation of machinery and auxiliary structures, which may be used to force the building components into the correct position is not within the scope of this article. Nevertheless, some of these structures and machinery are briefly described here.

2.3.2 Tie-Rods

Tie-rods can be fastened to secure parts of a structure at one end and to the section to be realigned at the other end. With the help of turnbuckles the displaced sections may be slowly moved toward their original position. Since tie-rods are always in tension, they can be of a relatively small diameter. In many cases tie-rods can be installed, concealed and left in place, without intruding on the visual integrity of a historic structure.

Tie-rods can be found frequently in historic buildings, either as part of the original design or part of the building's evolutionary development. Such tie-rods were usually installed with exposed, decorative anchor plates or escutcheons. The installation of imitation period plates may be considered contrary to good conservation practices.

Contemporary anchor plates may be designed in special shapes or painted in special colours to make them as inconspicuous as possible.

It is also possible to remove one layer of facing brick or facing stone and install anchor plates under the facing. After the installation the facing may be reinstated while the plate underneath remains concealed. It may also be possible to grout the end of tie-rods into solid walls, thus avoiding the necessity of anchor plates altogether. Precautions should be taken to avoid corrosion.

2.3.3 Shoring

Shorings are temporary structures which can be used to support the building parts during consolidation or reinforcement. The other, equally important role of shoring is the lifting or pressing of misaligned building parts into position. Vertical shorings are

basically columns which carry vertical loads. Diagonal shoring rests on ground foundations at one end and leans against a wall on the other. Horizontal shoring is used where the stationary end can be appropriately rested against a solid structure. In order to push building elements wedges or jacks are used.

Since there could be enormous pressures and stresses developing in shoring, their installation must be properly engineered and supervised.

Horizontal Shoring
Martello Tower #2, Quebec City, PQ

2.3.4 Belt

In this concept bracing can be compared to a belt which is tied around a building. Bracing can be made from timber, steel cable or other steel shapes. Flexible bracing may be tightened with turnbuckles. Rigid bracing is usually tightened with wedges or with flat jacks.

2.3.5 Internal Frames

When bulging, leaning or sagging is in the direction of the interior of the building then structural frames may be erected in the interior. These frames may then be used to apply pressure on vertical or horizontal components. Jacks or other devices will push outward against the misaligned parts.

For more information on shoring, bracing and internal frames, see Section 3.2.

2.4 GROUTING

Grouting is the injection of mortars into the cavities, gaps, cracks or joints of masonry structures. When this highly diluted mortar solidifies it consolidates the masonry into a strong mass. Grouting is a very complex process which must be executed by well-equipped and well-trained experts. This article attempts to provide an understanding of the process and is not intended to be a manual for grouting.

2.4.1 Use

Cavity Walls

a. Rubble-Filled Walls:
   Historically it was a common practice to erect neat outer and inner wall veneers and fill the space in between with irregular stones or bricks, embedded in a weak mortar. Many times this mortar disintegrates and the bond between the parts of the wall becomes weak. The disintegration of the mortar may create large cavities between the outer and inner layers.

b. Unit Masonry Joints:
   Unit masonry, be it cut stone, field stone, brick or other, is always embedded in and held with mortar. For various reasons this mortar may disintegrate. When this happens on a large scale, the mortar joints may be reconstituted by grouting. Note that grouting of loose jointed masonry is not the same as re-pointing.

2.4.2 Tensile Stresses

Grouts, like any other masonry material, can carry considerable loads in compression. However, like other masonry materials, grouts have only minimal strength in tension. Consequently, masonry grout should not be used without reinforcement where substantial tensile stresses may develop.

2.4.3 Composition

Grouts are very fluid mortar mixtures. The basic ingredients of most grouts are a cementing material and water. The cementing material can be Portland cement, hydraulic cement, masonry cement, specialty cements, lime mortar or a mixture of any of these. Like any other mortars, the grout should be weaker than the compressive strength of the masonry itself.

a. Additives:
   In addition to the basic materials, grouts most often contain additives to improve the flow, the penetration and the bonding of the grout within the masonry. Plasticizers and lubricants ensure that the consistency of the grout remains constant during the operation and that it will penetrate easily to minute cavities.

   Stabilizers prevent the separation of ingredients. Expanding agents ensure that the grout will not shrink while it sets. Certain others control the timing of the consolidation of grout; this will ensure that the grout will not solidify before flowing into all gaps. Certain polymers may be added to improve adhesion and increase tensile strength.

b. Aggregates:
   Aggregates such as sand can be used as inexpensive fillers. When sand particles are too coarse, then other materials, such as flyash, bentonite and other clayey substances are used.

2.4.4 Application

Grouts are injected into the masonry either under pressure or by gravity. There are many types of machines available for pressure grouting. It is very important to control the pressure of injection. If the pressure is too low then the grout will not penetrate into all open spaces. If the pressure is too high then the grout may burst the masonry apart. For gravity grouting, the mortar mixture is kept in a small container which is connected to the entry port with a flexible tube. By lifting or lowering the container the pressure head can be controlled.

In walls and other vertical structures, the injection of grout begins at the bottom and the grout is forced upward. When the lower part is filled then the injection begins at a higher elevation and so on. This method controls the injection better than filling from the top and letting the grout percolate downward.

The location of entry holes for grout injection must be selected very carefully. These holes, when drilled into the masonry, can create unwanted marks on masonry façades. If at all possible the injectors should be placed into the joint spaces between the masonry units.

Grout may be injected also through window or door openings. Sometimes it is possible to remove the window or door frames and then drill the injection holes into the walls at these openings. When the injection is completed the frames are reinstalled.

2.4.5 Cleanup

When grout is injected into masonry it may flow out unexpectedly through cracks or open joints. When solidified, this grout will adhere strongly to the masonry façade and its removal may damage the stones or bricks. Some types of grouts contain chemicals which may discolour the masonry or etch into it. Consequently several precautionary steps must be considered.

Very often the masonry is repointed before grouting with a low porosity mortar to prevent the seepage of grout through the joints. Under certain circumstances the joints and cracks are filled with an easily removable pliable sealer. After the grout has solidified the sealer may be removed and the joints properly repointed. If, regardless of all precautionary measures, some spill appears it must be washed away immediately. It is advisable to have a pail of water and brush available at all grouting operations.

2.5 STITCHING

Stitching is the reinforcement of fractured, cracked or separated masonry units with grouted-in-place inserts. It is important to note that stitching can carry tensile stresses which cannot be carried by grouted masonry alone.

Though stitching can carry tensile stresses, it should be attempted only after the causes of failure are eliminated. Stitching should correct faults which originate within the parts to be repaired and should carry stresses which are inherent to the structure itself.

2.5.1 Positioning

Stitching involves the drilling into the masonry, of diameter holes, of considerable length. The selection of the location requires complex engineering calculation and attention to detail in order to avoid defacing the building. Usually it is necessary to install several stitches in larger walls in order to distribute the stresses on the inserts.

2.5.2 Dimensioning

The dimensions of stitching are engineered with due consideration of several factors, such as bar strength and bond strength. The diameter of the reinforcing bar depends on the forces that may develop and on the strength of the bar material itself. The length of the stitching depends on the dimensions of the member which is being stitched and on the bonding strength of the grout.

2.5.3 Materials

The most frequently used stitching rods are deformed steel bars, commonly used for concrete reinforcement. The more expensive coated bars are used where corrosion may occur due to moisture penetration.

In special cases stainless steel or bronze bars can be used. Past experience shows that under certain circumstances even these may corrode or stain the masonry. Consequently, the selection of bar material should be the responsibility of professional conservators.

Good results are also achieved with glass fibre, Kevlar reinforced epoxy or polyester bars.

The grout which is used to bond the bar to the masonry is usually a high strength cement mortar that ensures sufficient bond strength. It is in most cases as strong or stronger than the masonry itself.

Occasionally epoxy and sand mixtures are used to grout the rods in place.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.1.2

STABILIZATION

MASONRY STRUCTURES: EPOXY REPAIR

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: P. STUMES

CONTENTS

1.0 INTRODUCTION

This article provides guidance for simple epoxy injection for loose unit masonry. It describes methods for using a manually operated injector to fill gaps in cracked masonry and for securing loose bricks and stones.

1.1 GENERAL REMARKS

The problem of cracks and loose masonry occurs in properties including contemporary buildings, historic structures and canal walls. When epoxy injection is warranted and the amount of work justifies it, one may engage specialists who will do the job with electrically or hydraulically operated epoxy injecting machines. However, for smaller jobs in remote locations, adequate results may be achieved using specially fabricated injectors of the sort described herein.

1.2 USERS

This information is for the use of CPS regional and local maintenance personnel who have been advised that the use of epoxy injection is a recommended method of repair. In all cases it should be stressed that application of epoxy is not reversible when used on historic masonry. Its use for historic structures must first be approved by a project team which includes qualified conservation professionals.

1.3 GENERAL EFFECTIVENESS OF EPOXY

Properly applied epoxies have considerable adhesive power and structural strength. It is possible to regain 60 - 100 percent of the original tensile compressive and flexural strength after cracks are sealed with epoxy. However, the method described here will not restore damaged reinforcing bars.

Since epoxy, when properly applied, is much stronger than most mortars, it can bind loose masonry units securely in place.

Seeping water may be sealed off by applying special epoxies which harden and adhere to masonry even underwater.

2.0 ASSESSMENT OF REPAIR WORK

When masonry cracks, gaps appear and the bricks or stones become loose. It is frequently a sign of failure in the structure itself.

Sinking or rising foundations, leaning of walls, overloaded beams, penetrating moisture, leaky roofs, inferior materials and shoddy workmansip are only a few of the causes of cracks and loose masonry units.

Sealing gaps or securing loose masonry will remedy the symptoms but usually will not cure the causes. Cracks may re-open and the bricks or stone could become loose again.

It is extremely important therefore, to search out the source of the problems and correct them before applying epoxy.

3.0 EPOXY RESINS

3.1 TYPES AND PROPERTIES

Epoxy is a synthetic resin with many possible applications. Depending upon the manufacturing process, the properties of epoxy may be altered to suit the intended usage. Among others, epoxy is the base material for several excellent adhesives. Epoxies, which are specially manufactured for repairing masonry or otherwise suitable for this purpose, may be purchased from building material suppliers or from plastic supply stores.

Epoxies are available in various viscosities. Some are easy flowing like cooking oil, while others are thick. There are epoxies in paste consistency as well. Epoxy pastes may be applied on vertical or overhead surfaces, without the risk of dripping.

Anyone about to use an epoxy should study the manufacturer's instructions beforehand.

Selection of the proper viscosity depends on the intended application. For hairline cracks one should choose a liquid epoxy; for closing larger gaps overhead, an epoxy paste is best.

Epoxy is a combination of two ingredients; resin and hardener. The two are sold together, in separate containers. The mixing ratio of the two components varies, but it is always clearly marked on the containers.

When the two components are mixed together, the mixture will harden within a short period. It should be clearly understood that the hardening does not happen by the evaporation of a solvent. The molecules of the two components link into a chain and in the resulting solid both ingredients are present. The volume of the hardened epoxy is the same as the volume of the liquid ingredients.

The structural strength of an epoxy depends on many factors, such as the manufacturing process and the care exercised during mixing. Usually manufacturers can provide data sheets, including information about the structural properties.

In general, the allowable stresses of epoxies will fall into the following range:

- Adhesive strength: 2000 – 6000 kPa
- Compressive strength: 6000 – 25 000 kPa
- Tensile strength: 6000 – 13 000 kPa
- Flexural strength: 6000 – 20 000 kPa

3.2 ADJUSTMENTS FOR VARIOUS CONDITIONS

If epoxy is used to fill wide gaps (5 mm or more), mix it with up to 45 percent of filler, by weight. The best filler for this purpose is stone dust. If it is difficult to obtain, use Fuller's Earth instead. Fuller's Earth (Diatom Earth) is available from swimming pool suppliers where it is used for filtering water.

Common epoxies should be applied on dry masonry only. If the masonry is wet, then special epoxy should be purchased which hardens and adheres to masonry materials even under wet conditions.

In very warm weather or in overheated spaces (near 30°C), the epoxy might harden too fast. To slow down the hardening, mix the epoxy in a cold room, place the mixing dish into a pail of cold water or store in a refrigerator until it cools down to about 10°C.

Below 5°C certain epoxies will not harden. In cold weather mix the epoxy in a warm room and/or blow hot air on it for a few minutes after injection.

Never try to warm epoxy on a stove, hot plate or similar device.

Most epoxies will harden within 30 to 60 minutes, but they do not reach their full strength for another 24 hours.

Test a small batch on a sample of similar masonry units before applying it to historic structures.

4.0 HANDLING PROCEDURE

Never contaminate the epoxy hardener and resin with unknown substances. Accidental contamination could completely alter the properties of ingredients and prevent the desired chemical reactions.

Always use a separate measuring dish, scoop, stirring rod, etc., for each ingredient. Since the materials of certain utensils may also contain contaminants, use glass or metal utensils whenever possible. Mark each utensil to prevent accidental confusion of ingredients. Use a separate dish for combining the ingredients and never use the measuring dishes for this purpose.

Measuring dishes and scoops may be washed clean with methyl hydrate or with an organic solvent, manufactured for laboratory cleaning purposes. The cleaning must be done immediately after using the utensils, while the ingredients are still in liquid form. After the hardening process begins, the epoxy cannot be dissolved.

Never mix different brands of resins and hardeners.

The ingredients should be measured to an accuracy of one percent and the procedures for combining are:

a. measure the required amount of resin and pour it into the mixing dish;
b. add the hardener;
c. mix thoroughly with a high speed electric mixer for at least one minute (use a propellor-type stirrer in an electric drill) or mix by hand for three minutes; and
d. add filler and mix thoroughly until it is smooth and has a uniform consistency.

The mixed epoxy should be used immediately. Never prepare a larger batch than can be applied within 30 minutes. After that time the polymerization process accelerates and the material may become too stiff to handle.

5.0 SAFETY PRECAUTIONS

a. Before handling the ingredients, read the manufacturer's instructions carefully.
b. Do not smoke or use an open flame while handling any of the ingredients.
c. Do not inhale the fumes of the ingredients. Work in a well-ventilated space.
d. All ingredients are poisonous. Do not use near food or drink.
e. Extended contact with epoxy may cause skin irritation. After using, wash hands with clean alcohol or nail polish remover and then soap. It is advisable to use gloves while working with epoxy. Inexpensive disposable gloves are ideal. These do not collect contamination as do the durable, more expensive rubber gloves.
f. There is no solvent for hardened epoxy. Clean up spillage immediately with a solvent before it hardens. When working with epoxy, take care of clothing. Epoxy spots can never be removed.

6.0 THE MANUAL INJECTOR

A manual epoxy injector can be fabricated by slightly altering an automotive oil suction gun. One suitable type is the Canadian Tire No. 28-2620.

Such suction guns have a metal cylinder approximately 50 mm in diameter, 250 mm long. There is a neoprene plunger and 9.5 mm inside diameter vinyl discharge hose.

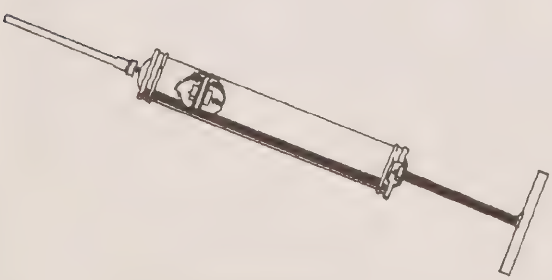

Fig. 1 – Fabricated Manual Epoxy Injector

Discard the plunger rod which is supplied with the suction gun. Replace it with a 10 mm or 12 mm diameter threaded rod and nut, as shown in Fig. 1. By turning the threaded rod, the required pressure can be exerted on the plunger without effort.

The cylinder of the injector may be filled with approximately 500 ml of epoxy, either moderately thick liquid or paste.

The injector should be disassembled and washed in solvent after every use before the epoxy hardens. It is impossible to clean after the epoxy sets. This operation is usually done every 30 minutes, depending on the type of epoxy used.

Disassembling, cleaning and reassembling the injector usually takes 2 to 5 minutes.

7.0 SEALING CRACKS

7.1 PREPARATION

Before injecting epoxy, clean the gaps. Blow out dust with compressed air.

Epoxy will not adhere to oil, grease or other petroleum products. If the crack contains such material, clean it first with varsol, then rinse with methyl alcohol. Apply the epoxy after these solvents completely evaporate.

To prevent the epoxy from dripping out from the unit masonry during injection, seal the openings first with a suitable modeling material such as Harbutts plasticine. This material is pliable, seals uneven gaps well and may be removed easily after the epoxy hardens. It will not adhere to the epoxy. Any traces of the modeling material may be removed from the surface with methyl hydrate.

The injected epoxy may be concealed with mortar or artificial stone. Fill cracks approximately 25 mm deep with modeling material before injecting the epoxy. After the epoxy hardens, remove the modeling material and fill the gap with the desired mortar or artificial stone mixture.

Plasticine or other types of modeling material may be purchased at art supply or hobby stores.

7.2 INJECTION

To fill wide gaps, simply insert the vinyl hose into the opening and inject the epoxy.

For narrow, long or deep cracks, when it is necessary to exert higher pressure, set a small diameter copper tube into the opening. The outside diameter of this copper tube should fit snugly into the vinyl hose. Normally about 30 mm length of the tube should be set into the masonry. Approximately 50 mm of the tube should protrude for connecting the vinyl hose. Usually the friction between the tube and the hose is sufficient to provide a strong connection.

Occasionally it may be necessary to secure the hose on the tube with a small hose clamp. When placing the copper tube into a narrow gap, sometimes it is necessary to flatten one end of the tube somewhat. If the gap is too narrow, a hole centred over the gap should be drilled for the tube.

When the surface of the crack is sealed to prevent the epoxy dripping out or when the gap is very long, install an injector tube every 300 mm to 600 mm. Start injecting the epoxy through one tube and when it begins dripping out the next tube it is an indication that the section is filled. Close the first tube by flattening and bending back. Resume injecting at the second tube until epoxy drips from the third tube and so on.

8.0 SECURING LOOSE UNIT MASONRY

Loose brick, building stone, concrete block or other unit masonry may be secured in place with epoxy anchors. Such anchors should preferably be placed into the joints between the units. If the anchor is set beyond the face of the masonry it can be concealed with mortar.

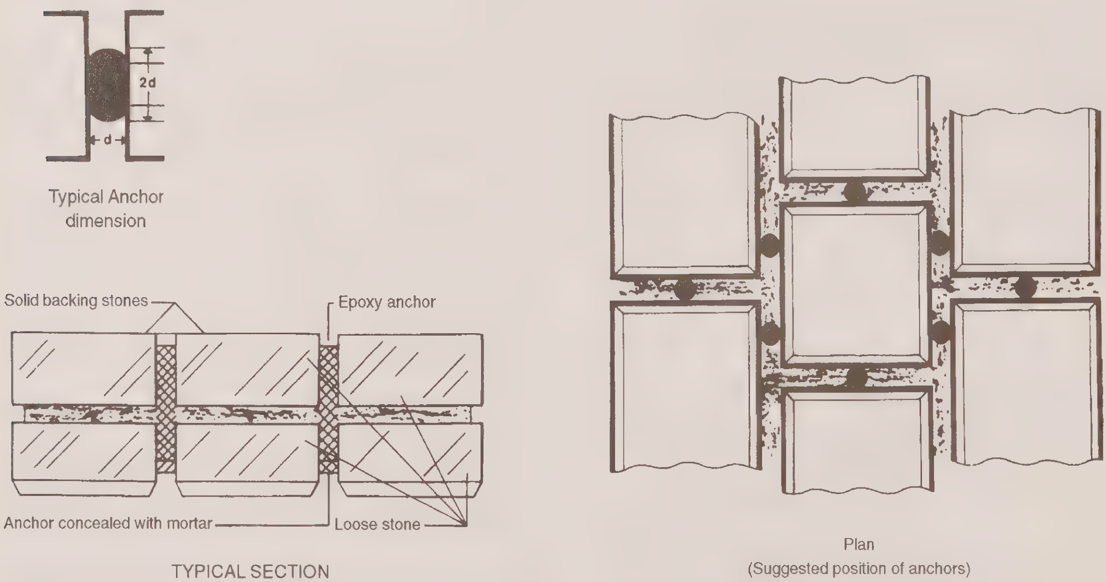

Fig. 2 – Using Epoxy Anchors to Secure Loose Unit Masonry

Make holes for the anchors by drilling into the mortar of the joint with a masonry drill. By tilting the drill in both directions along the joint it is possible to make an oval hole of the necessary dimension. (See Fig. 2).

Place the vinyl hose into the hole and fill with epoxy paste. When the epoxy hardens the anchor is ready. For the best result position the anchors evenly around the perimeter of the unit, one or more on each side, using paste-type epoxy. It is a good practice to drill the anchor-holes into the solid masonry behind the loose unit. Such anchors are usually much stronger than simply drilling into the mortar between two stones.

The load-bearing capacity of anchors depends on many factors, but the average capacity may be calculated from the following table:

LOAD BEARING CAPACITY

Diameter of Anchor	Load Bearing each
5 mm	25 kg
10 mm	70 kg
12 mm	100 kg
15 mm	125 kg
20 mm	160 kg
25 mm	200 kg

These loads may be exerted on the epoxy anchors 24 hours after it hardens.

VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.1.3

STABILIZATION

MASONRY STRUCTURES: REPOINTING

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1.0 INTRODUCTION

In unit masonry structures the bricks or stones are laid in a mortar bedding. From the earliest of times, Canadian masons paid special attention to the finishing of this mortar on exposed surfaces of structures, particularly walls.

Proper finishing increased the resistance to damaging environmental conditions. It sealed the mortar joints against the penetration of moisture and lessened the effects of freeze-thaw cycles.

Neat finishes enhanced the appearance of the wall, so much so that they were frequently applied as decorative elements.

The process of finishing the mortar at the exposed surface is called "pointing." Pointing is relatively easily done when the stone or brick is laid.

This pointing, like any other part of a structure, deteriorates over time. In order to preserve the structural integrity and authentic appearance of period masonry this pointing must be repaired periodically. The process of repairing this pointing is called "repointing."

The purpose of this article is to explain, in general terms, the process of repointing. It is intended for staff who are responsible for the maintenance of historic structures. It should enable maintenance staff to determine when repointing becomes necessary and to specify and recommend an approach. This article is not intended to serve as a "how to" manual for labourers who carry out this work. It is essential to find tradespeople who have experience with the types of mortar described in this article or to arrange for a master mason with such experience to train and direct the tradespeople at the outset of the project.

2.0 DETERIORATION

Prior to the repointing operation, it is important to find out the causes of deterioration. If these causes are identified and understood, then appropriate corrective measures can be instituted to prevent further problems and reduce the frequency of future repointing.

Deteriorated Mortar

2.1 QUALITY OF POINTING

Poor workmanship and inferior materials are the two most common problems related to repointing quality. Poor workmanship includes situations when the pointing mortar was not tamped in place to a firm consistency; the mortar was spread intermittently, leaving minute spaces between blobs of material; inappropriate shape of pointing promoted the accumulation of deleterious substances; or the surfaces of bricks or stones were left dirty, preventing proper adhesion of mortar to masonry.

Inferior quality resulted when the mortar mix was prepared with too much (or too little) water; the water contained salts organic matter or other deleterious substances; insufficient or poor quality lime or other cementing material was used; sand with unsuitable particle distribution, usually with too large grains, was used; chemically unstable sand initiated a decaying reaction between the constituents of the mortar; or the ingredients of the mortar were not mixed thoroughly.

All problems caused by the quality of pointing can be prevented by clearly specifying the appropriate materials and working procedures plus adequate supervision of the work in progress.

2.2 DEVELOPMENTAL PROBLEMS

Causes which develop during the lifetime of the masonry include the following three general areas:

a. Environmental conditions:
   - decay of mortar due to atmospheric pollutants;
   - decay caused by acid rain;
   - water infiltration on walls exposed to prevailing winds;
   - accumulation of salt crystals from road salting; or
   - fractured mortar due to freeze-thaw cycling.

b. Organic substances
   - degradation of mortar by lichen and moss;
   - cracking up of mortar by roots from vegetal matter;
   - consumption of lime by birds or other animals chipping away the mortar; or
   - vandalism.

c. Structural problems:
   - fracturing of mortar under the weight of the building; or
   - movement of the structure, causing cracking of mortar or disengaging the bond between ma sonry and mortar.

2.3 MOISTURE ACCUMULATION

While moisture accumulation could be discussed under Section 2.2, due to its serious implications it is covered in more detail under this separate section.

Effects of moisture penetration:

a. constant wetting may dissolve and wash away the lime content of the mortar;
b. when water with high salinity evaporates, the growth of the remaining salt crystals will crack the mortar; or
c. volume changes occur during freeze-thaw cycles and generate stresses beyond the strength of the mortar.

Sources of moisture in walls:

a. in poorly designed buildings the downpour from roofs can splash on parts below;
b. leaky roofs, eavestroughs or downspouts;
c. leaking water lines, sewers or equipment; or
d. high ground water level or ponding surface water.

Prior to repointing the masonry, analyze and correct all faults and eliminate sources of moisture penetration whenever possible.

3.0 INSPECTION

Inspect the condition of the pointing regularly, for example, once a year.

Visual inspection may reveal severe cracking of the mortar or pieces of pointing deteriorated and missing to a considerable depth. The inspector may observe a powdery substance in place of pointing. A good indication of deterioration can be found on the floor next to the wall or on the ground in the form of fallen pieces of mortar or accumulated powdered mortar.

It is also advisable for the inspector to poke in the joints gently with a sharp instrument. This reveals cracked, loose or weak consistency mortar which cannot be discerned by simple visual inspection.

If the inspection reveals severe deterioration, the cause of this should be detected and corrected before the masonry is repointed.

4.0 JOINT CLEANING

Prior to repointing, the joints between the brick or stone must be thoroughly cleaned. Loose mortar should be picked out and old mortar should be cut back two to three times the height of the joint.

Ensure that the joint cleaning and removal of old mortar is done with a suitable instrument, such as scraper bar, trowel or chisel. It is advisable to use a wooden scraper for cleaning out the joints between very soft bricks.

Discourage any use of power tools because they can easily damage the brick or stone. If, in exceptional cases power tools are used, then the blade must be much thinner than the joint to avoid cutting into the masonry. Test the use of power tools at some concealed surface before proceeding with the whole wall. Ensure that the use of power tools is demonstrated to the responsible engineer or architect. The use of power tools may not proceed without the engineer's or architect's approval and continual supervision will be required throughout the progress of the work.

Joint Cleaning

Following the removal of mortar, clear all joints of loose particles and dust with a high-pressure air blower.

Frequently inspect the work during joint clearing operations to ensure that the edges of bricks or stones are not damaged by careless workmanship.

Inspectors may find that in the past someone had used hard, non-flexible cement mortars to repoint or repair structural faults in masonry with softer units, such as very soft brick. Make every reasonable attempt to remove all such mortars. However, if their removal would risk damaging the masonry units themselves, it is better to leave the cement mortars in place until new removal techniques are perfected which do not damage the masonry units.

5.0 MORTAR PREPARATION

Select and specify the mortar which will be used for repointing with extreme care. Its properties have great impact on the durability of the structure, as well as on the visual authenticity. Pay special attention to the following structural properties.

5.1 STRUCTURAL QUALITIES

a. Adhesion:
In order to seal the joints against penetration of moisture, wind, dust, etc., the mortar must adhere firmly to the masonry. This can be achieved by cleaning the masonry surfaces thoroughly with special attention to removing all oily or organic substances. The use of sufficient amounts of good quality lime and cement will help to ensure proper adhesion.

b. Strength:
The mortar must have sufficient strength to bear the crushing load of the masonry above and resist the stresses of lateral movements in the wall. However, the mortar in all new repointing work should not be stronger than the brick or stone itself. It is advisable to prepare a mortar which is 15 - 25 percent weaker than the masonry units. This will ensure that in case of high stresses the mortar will fail before the bricks or stone. It is much easier to repair the mortar than to repair cracked or broken masonry.

c. Pliability:
Historic mortars with high lime content remain pliable for a long time, capable of adjusting to the movements of the masonry. This is one of the reasons to avoid using mortars with high Portland cement content and to encourage the use of historic recipes.

d. Workability:
The mortar used for repointing must be sufficiently soft to completely penetrate the joints and gaps. At the same time it must be firm enough to keep its shape after formed in place. Proper consistency can be achieved by careful proportioning of all the ingredients. It is advisable for the mason to prepare test batches of mortars and try them out in inconsequential locations. If, for some reason, proper consistency cannot be achieved with natural ingredients then commercially available additives may be used in very limited quantities. Different brands of additives can be

purchased from building supply merchants. When repointing historic masonry every effort must be made to achieve proper mortar consistency with natural ingredients. Certain additives may change the properties of the mortar in ways which are not consistent with good conservation practice.

Mortar Preparation

5.2 VISUAL QUALITIES

To preserve the visual authenticity of historic structures, the colour and texture of mortar used for repointing must closely resemble that of the historic mortar. This is especially important when only part of the structure will be repointed. Nothing spoils the appearance of a new repointing job more than mismatching mortar lines on a wall.

The best method to approximate the visual qualities of old mortars is to prepare the new with the original ingredients in the same proportions as well as can be established. Most of the time there are no records of the type of ingredients used in the past. One of the recommended methods of matching old mortars is the preparation of trial batches, using various ingredients in different proportions and comparing the test mortars to the original ones.

The process can be much simplified if the original ingredients can be identified or at least approximated, by using modern test methods. These tests cannot normally be carried out in the field. However, most conservation laboratories have the equipment to analyze the component parts of historic mortars.

At the present time there are no quick, easy or economically feasible tests which can provide complete information about the ingredients and their proportions. However, there are some tests which can give fair indications of the original constituents of the old mortar. Using the results of these tests, the guesswork and the number of test batches, can be reduced to manageable proportions.

Three available test methods are known by the originators' name and the year they were introduced:

- H. Jebrzejewska, 1960
- E.B. Cliver, 1974
- A.S.T.M. Des. C85-66, 1971.

These three tests may make it possible to estimate the proportions of lime, sand, Portland cement, natural cement and clay used for the original mortar. It must be emphasized that none of these tests provide exact results or 100 percent complete information.

Much useful information about the chemical composition of mortar can be obtained through X-ray defraction analysis. This analysis requires special equipment and expert interpretation of the results. The necessary equipment is available at many universities, commercial testing laboratories and conservation institutes. Interpretation of the results may be obtained from building materials scientists and from chemists with experience in historic resource conservation.

Since the type of sand used in preparing the mortar has great influence on the appearance and durability of the mortar, it is a good practice to analyse the sand content as accurately as possible. The first step in analysing the sand is to separate it from the binding materials, such as lime and cement. This is usually done by dissolving the binders in a suitable medium.

The freed sand is usually submitted to standard soils engineering examinations and used to determine the ratio of sand to binder by weight and by volume, the mineralogical identification and distribution of the different sizes of particles.

It must be emphasized that, due to environmental influences, the appearance of mortar usually changes with age. Therefore, it is a good practice to prepare test batches a long time before repointing becomes necessary and to expose them to the same conditions as the original mortar or to use accelerated aging tests. The optimum would be to expose the test batches to at least one or preferably two, complete changes of seasons, representing one or two years of exposure.

The ingredients of test batches must be carefully recorded and the records preserved in the project dossier. Once the correct combination is found, the project files and records will make repointing much easier, when it becomes necessary again, in the future.

5.3 MORTAR COMPOSITION

Using different tests it is possible to determine approximately the composition of historic mortar. The results may be further refined if we know the ingredients which were customarily used in period mortars.

At the earliest times a type of clay putty was used as mortar, before lime kilns could be built in the Canadian wilderness. Though it deteriorates quite quickly, traces of clay putty mortar may be found infrequently in older masonry buildings. In most cases, when lime mortar became available sometime later, the masonry structures were repointed with lime mortar, though the masonry may have been originally laid in clay putty.

From the 17th century on, the making of lime became a commonly practised industry in Canada. Lime was manufactured usually by oxidizing limestone in especially built kilns. Due to lack of experience in quality control there is a great difference between the products coming from different kilns or even between products coming from the same kiln at different periods. These variations add to the importance of experimenting with test batches when trying to match older mortars.

Proximity to the ocean shorelines sometimes meant there where large deposits of seashells. These were used as base materials for making lime when they were available.

Most lime was made from more or less pure limestones, producing the so called "fat lime." This lime had to be slaked in water for a day or two before it could be used in mortar. Today, so-called prehydrated limes are available which are more convenient to use and can replace old type lime in all aspects. See also Vol. VI.3.1, Section 3 "Types of Mortars."

Pure lime mortar is neither very hard nor stable. It becomes quite soft when wetted but these properties have some advantages. For example, pure lime mortar is always weaker than the masonry unit it bonds, and under the influence of humidity, lime regenerates itself, resealing gaps or cracks.

When the limestone contained clay and other impurities, the manufactured lime became the so called "hydraulic" lime. This type of lime will become very hard when exposed to water and it will not become pliable again when wetted. The main advantage of this type of lime is its high crushing strength and its relative resistance to deterioration. The high strength may be a disadvantage when the mortar becomes stronger than the masonry itself.

Today Portland cement is usually substituted for hydraulic lime. When a light coloured mortar is desired, a nearly white "masonry cement" is used.

To obtain a mortar with the desired strength and durability, usually both lime mortar and masonry cement are combined at a different ratio, in addition to sand and water.

As mentioned previously, the historically correct mixture of ingredients may be obtained only by preparing trial batches and comparing them to the original mortar. However, as a starting point the use of the following mixtures are recommended. (All listed quantities are in units of volume.)

Masonry type	Cement	Lime	Sand
Very soft	0	2	5
Soft	1	3	10 – 13
Medium	1	2	8 – 10
Hard	1	2	5

Note: Add a sufficient amount of water to achieve the desired consistency and workability.

To improve the pointing's resistance to weathering, a commercially available air-entraining agent may be added to the mortar. Incorporate other additives only if absolutely necessary to improve workability or obtain other desirable properties. The type and amount of additives is usually recommended by the supplier or manufacturer.

Occasionally, it may be desirable to add colourings to the mortar, either because the original mortar also contained colourings or because the original colour cannot be duplicated otherwise. Since most organic or synthetic pigments will fade when exposed to the environment, only chemically pure mineral oxides should be used as colourings.

6.0 REPOINTING

6.1 WORK PREPARATION

Prior to the application of repointing mortar, rake and clean the joints completely, as described in Section 4.0. Gather all necessary material in sufficient quantities for making the pointing mortar according to the composition of the approved trial batch. Provide safe, secure and sturdy scaffolding to the necessary height.

6.2 REPOINTING OPERATIONS

Immediately prior to applying the mortar, wet all exposed surfaces of the cleaned masonry joints. If the masonry is dry when the mortar is applied, then a large amount of water will be soaked up by the masonry, leaving the mortar too dry. If there is not sufficient water in the mortar, then it will not cure properly.

Ensure that the mortar is prepared in small batches, just enough to satisfy the immediate requirements of the mason. If a large amount of mortar is prepared in advance, it may start hardening before it is set in place.

If the gap is more than 10 mm deep, ensure that the mason fills the joints in several layers. If the depth of fill is more than 10 mm, then the mortar will not cure evenly throughout.

Apply the mortar in about 5-8 mm deep layers, well pressed in place to a firm consistency. When the layer is cured to a consistency that it cannot be pressed in with a thumb, the next 5-8 mm layer may be applied. Repeat this process until the joint is filled up to the face of the masonry.

When the final layer of mortar is thumb-print hard, tool the joint to match the historic mortar. Match the shape of the finishing layer of pointing to that of the original finish. Sample of finishing shapes are illustrated in Fig. 1.

6.3 CLEANUP

After the pointing is completed, ensure that the masonry façade is cleaned of spilled mortar. The cleaning should be done immediately after the mortar in the joints has begun to harden. Usually the relatively fresh spills can be removed with low-pressure clean water and bristle brushing.

If the spilled mortar cannot be removed with this method then use other chemical methods, applying systems appropriate to historic masonry.

7.0 ILLUSTRATIONS

Fig. 1 Pointing For Historic Masonry

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.2

STABILIZATION

WOOD STRUCTURES: SPLICING AND REPAIR

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1.0 INTRODUCTION

Failure or deterioration of a historic timber structure can usually be traced to some localized deterioration or defect which can be repaired selectively (Fig. 1). However, the actual method to be used for its repair can be the subject of some controversy due to the variety of techniques available, variations in specific site conditions and philosophical and aesthetic considerations.

Conservation action on historic timber structures has at least one of these principal objectives:

a. to restore the deteriorated member or structure to its original load bearing capacity;
b. to increase its load bearing capacity;
c. to restore its appearance;
d. to arrest decay; or
e. to stabilize whenever structural failure is evident.

Several different procedures or approaches are widely used in the conservation of wood in historic structures. Briefly these are:

a. chemical preservative treatments or the use of toxic materials to eradicate wood destroying fungi or insects;
b. addition of a supplementary load bearing structure in steel or wood;
c. stabilization of friable material through impregnation with chemical consolidants;
d. reinforcement or replacement of deteriorated or missing wood with polyester resins; and
e. selective repair and reinforcement of deteriorated members by splicing in new sound material or complete members.

This article describes the last of these, the principal techniques and materials which are used for selective repair of deteriorated timber structures. (Techniques based on the use of epoxies are not considered in depth as they have been adequately described elsewhere. See the Bibliography for references and also Section 4.2.1 "Stabilization – Wood Structures: Chemical Consolidation.")

2.0 GENERAL CONSIDERATIONS

The essence of partial replacement or selective repair is that the structure functions as it was originally intended. Fig. 1 illustrates how a case of apparently widespread and general deterioration is in fact sequential and localized. The repair program for this structure must respond to that condition.

The actual repair of complex timber structures is both technically and philosophically challenging.

It is crucial that a number of criteria concerning the condition and desired performance of the structure be identified before selecting a repair technique and proceeding with it.

a. Cause of deterioration: as Fig. 1 shows, deterioration in a timber structure seldom occurs at the location of the symptom. The fault must be traced back to its origin.

b. Environmental factors: timber members located in a confined space, in association with an important artifact or in a place which is inaccessible to regular inspection may require the use of quite different conservation techniques.

c. Historic significance: this may be determined by the manner in which timber is utilized in construction or decoration, evidence of toolmarks, evidence of occupation and building use. Historic importance may require that the member be retained in its entirety and that the loads be carried by some other means.

d. Ultimate Use: the planned use of a member is a crucial determinent for its treatment:

   - the structure or member is restored to its original strength and purpose
   - its load bearing capacity is increased to meet modern requirements
   - its appearance only is restored
   - the repair primarily is to arrest decay
   - the structure or member is stabilized to prevent collapse.

e. Availability of materials: sources of supply should be identified well in advance. If suitable sizes in the correct species are not available it may be necessary to use a lamination system to build up to the required dimensions.

f. Load bearing requirements should be checked to determine whether the structure is to continue in its old use or if the use is changing.

g. Conservation state of the element: the conservator should consider and understand the structure as a whole rather than as a collection of elements. Regardless of its present condition the structure was at one time probably capable of satisfactory performance. (See Vol. III .5 "Structural Engineering Analysis.")

h. Repair of wood structures can be approached from several different and contradictory philosophical points of view:

- repairs should be carried out without causing overstiffening of timber frames
- repairs should be carried out subtly in the manner of normal maintenance
- every scrap of historic material should be retained at all costs
- repairs should be carried out with current technology and materials in order that they take their honest place in the chronology of the building.

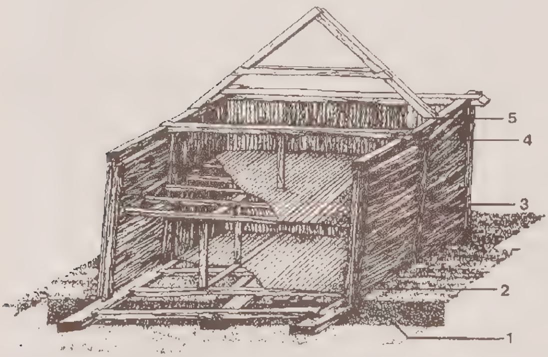

Fig. 1 Schematic structural diagram of the General Warehouse & Fur Store at Fort St. James, BC. The south sill has decayed and failed at (1) due to poor drainage and inadequate foundation design. The wall filler logs (2), and the post (3), have settled away from the top plate (4) disengaging the post tenon from the plate mortise. As the south wall settled the tie dovetail (5) disengaged from the top plate. The rafter ends then either pull away from the plate or were pulled down causing deformation on the ridge.

3.0 DEFINITIONS

a. Blade: A form of tenon located at the butts of a scarf or lap joint to provide greater efficiency in bending. Also referred to as a "bridle" or an "open mortise" (Fig. 2).

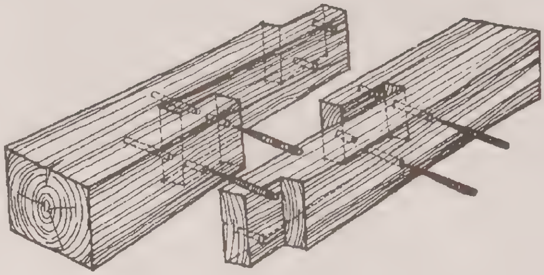

Fig. 2

b. Bridle: As in "blade."

c. Birds-mouth: Notch cut in the foot of a rafter for the purpose of seating it squarely on a top-plate.

d. Crows-foot: A joint designed to transfer compression stresses from a member meeting another at less than 90° from a rafter to a plate. Also called a foot-mortise (Fig. 3).

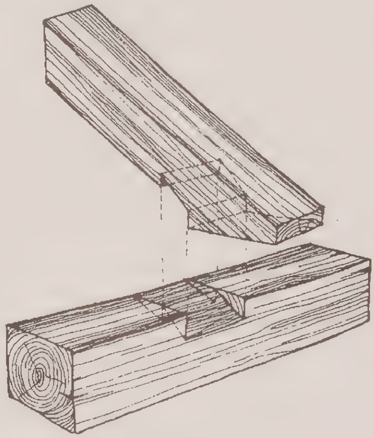

Fig. 3

e. Draw-pinning: (also draw boring, draw-bored and pinned) The holes for locating the pins of two members to be connected with a joint are bored slightly offset (about 5 mm) so they are pulled together when the pin is driven. The pin is tapered for about one-third of its length.

f. Edge-halved: A scarf joint with square vertical butts and surfaces parallel to the length of the timber. Used mid-wall to extend base and top plates and for joining corners in frame construction. Also called "lap joint" and "face-halved" when the joint is placed vertically. (Fig. 4).

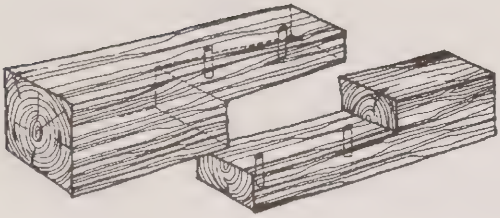

Fig. 4

g. Fish: An internal stiffening member for a beam, lintel or rafter. Can be of metal, wood or plywood (Fig. 5).

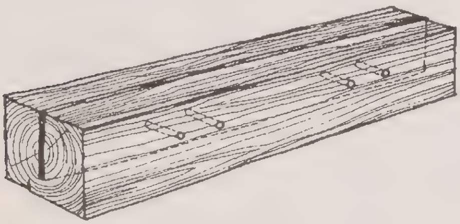

Fig. 5

h. Gusset: A short member fixed externally across a joint or fracture in a beam or rafter in the manner of a splint to strengthen it. Also a "flitch" (Fig. 6).

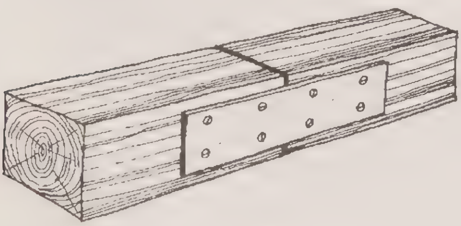

Fig. 6

i. Lap: As in "edge-halved."
j. Scarf: A group of joints designed to make long timbers of uniform depth and width from several short timbers (Fig. 4 & 8).
k. Shoulder: Surface of wood perpendicular to a tenon or dovetail. Occasionally set into the timber to which it is joined as in shouldered mortise and tenon. (Fig. 7).

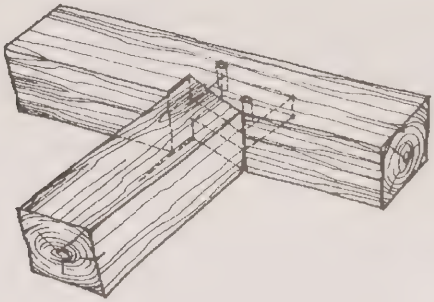

Fig. 7

l. Splay: A scarf joint with surfaces which are cut at an angle to the length of the timber (Fig. 8).

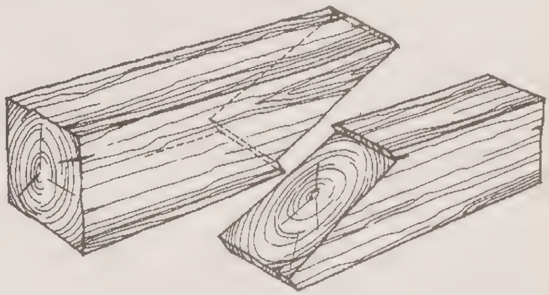

Fig. 8

m. Table: A step in a splay positioned to provide greater efficiency of the joint in tension (Fig. 9).

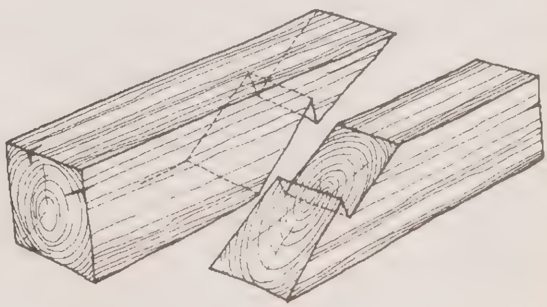

Fig. 9

n. Pin: (also peg) A short length of wood split to an irregular, roughly circular shape and tapered for about one-third of its length. Pins are used in heavy timber frame construction to locate structural elements accurately in relation to each other. They are not intended to transfer major stresses.
o. Log-End: (overhang) In log building, that part of the log beyond the notch.

4.0 MATERIALS AND METHODS

a. Dowels, bolts and clamps: These techniques are normally used to improve the performance of a joint, to repair a single element which has broken into two or more pieces or to prevent a crack or split from developing further. Dowels can be of metal, fibreglass reinforced polyester or most often, wood. The dowels are inserted with a small amount of the appropriate adhesive in holes drilled at alternate angles to achieve a "dovetail" effect. Metal bolts and wood clamps are surface inlayed (Fig. 10 a – b). Epoxy patching compounds are also used for repair of longitudinal seasoning checks and cracks in posts.

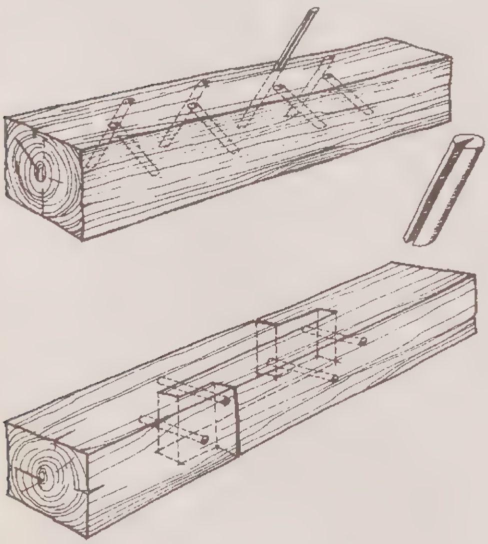

Fig. 10a Dowelling with rods of wood or other material bedded in a suitable adhesive.

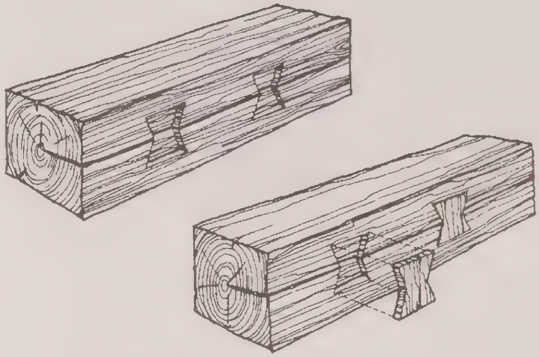

Fig. 10b Clamps or wedges are a traditional method of preventing the spread of cracks.

b. Bolting: If a stronger reinforcement is required than dowelling or wedging can provide, various types of bolts or screws can be used. Both heads and nuts should be concealed by deeply counter sinking and covering them with circular wooden plugs or "pellets" finished flush. A plug cutter or hole saw should be used to cut the plug. (Dowels should not be used as plugs due to the possibility of cross-grain shrinkage [Fig. 11].)

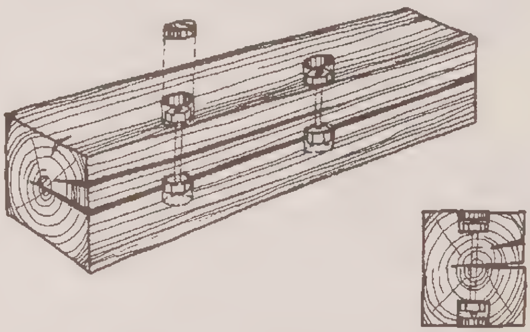

Fig. 11 Countersunk bolts and screws present considerable resistance to splitting. Large washers and metal plates can be used in conjunction with the bolts if required.

c. Replacement and joining: In this technique wood and suitable, traditional carpentry joints are used to replace deteriorated portions of timber members with sound, new material. "Splicing in" can provide an unobtrusive repair, suitable for locations open to public view (Fig. 12). The

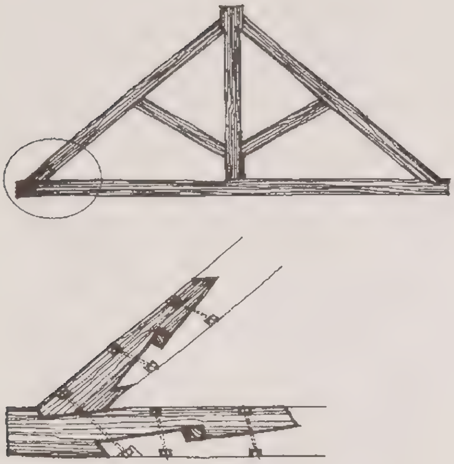

Fig. 12 A wood frame repaired by replacing missing or deteriorated sections with new materials spliced in with appropriate joints.

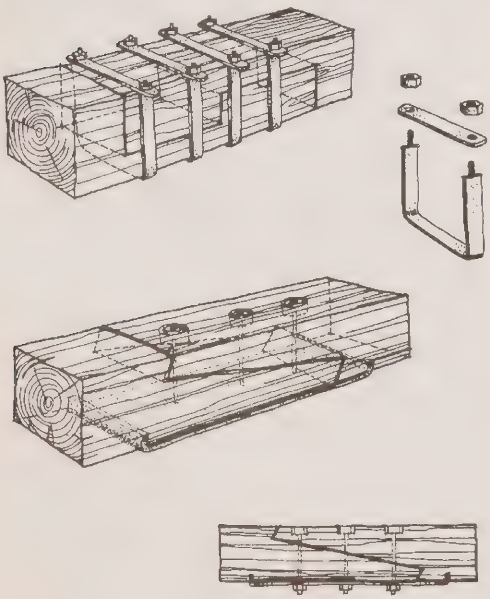

Fig. 13 The joints supplemented with bolts, metal plates and "U" bolts.

labour involved in cutting and fitting joints is considerable. If the joint is complex this can be an expensive repair technique. The joints can also be supplemented with bolts or gusset plates in the fashion of 19th-century heavy timber frame construction (Fig. 13). It is also essential that replacement timber be well seasoned and, if possible, be stored for several months in the place it will be used. All surfaces of a joint should be in full contact with the adjacent surface to ensure a properly functioning connection. Splicing in new material is an ideal technique for in situ repairs of column bases, beam ends and similar applications.

d. Lamination: the deteriorated area of the member is cut back in a series of steps and several layers of wood progressively glued into the opening. Laminates of 27-75mm thickness are preferred. The joints in adjacent laminates should be offset and the grain reversed. This technique is useful for repair of small areas of deterioration, for filling old pipe and duct chases. It is also to provide replacement material when large sizes of suitable timber are not available (Fig. 14).

e. Splinting: this is the technique of transferring the load on a deteriorated structural element to other sound elements such as fish plates or gusset plates. The plates are normally made of wood, plywood, metal or fibreglass-reinforced plastics. These are fixed, internally or externally at the deteriorated member with bolts, dowels or adhesives. Splints or fish plates were quite commonly used in 19th-century heavy timber construction to supplement carpentry joints. Splinting has been termed an "honest" repair technique as the repair is clearly visible and not disguised in any way. In some circumstances this "honesty" can be visually obtrusive and a more subtle approach is called for (Fig. 15). The advantage of a splint is that it permits the use of a less sophisticated and therefore less expensive joint. Splints should not be used to make up for the inefficiency of an entirely inappropriate joint.

5.0 REPAIR OF POSTS, STUDS AND COLUMNS

When repairing compression members with splices the objective is to achieve maximum contact of the interfaces to ensure the transfer of loads across the joint in a straight line parallel to the grain of the wood. The optimum compression joints are the scissors scarf and the simpler lap scarf with undercut butts. A variety of dovetail and mortise and tenon joints are also suitable. (Fig. 16 a – b). If some horizontal loads are present it is advisable to use metal or wood fish plates or gussets. Simpler joints can be used with these accessories. However, butt joints are not recommended (Fig. 17). In situ repairs can be simplified by use of such devices as false tenons, slot mortises or wedge tenons (Fig. 18 a – b). Lamination can also be used for repair of columns or posts. Adequate propping and bracing should precede all repairs.

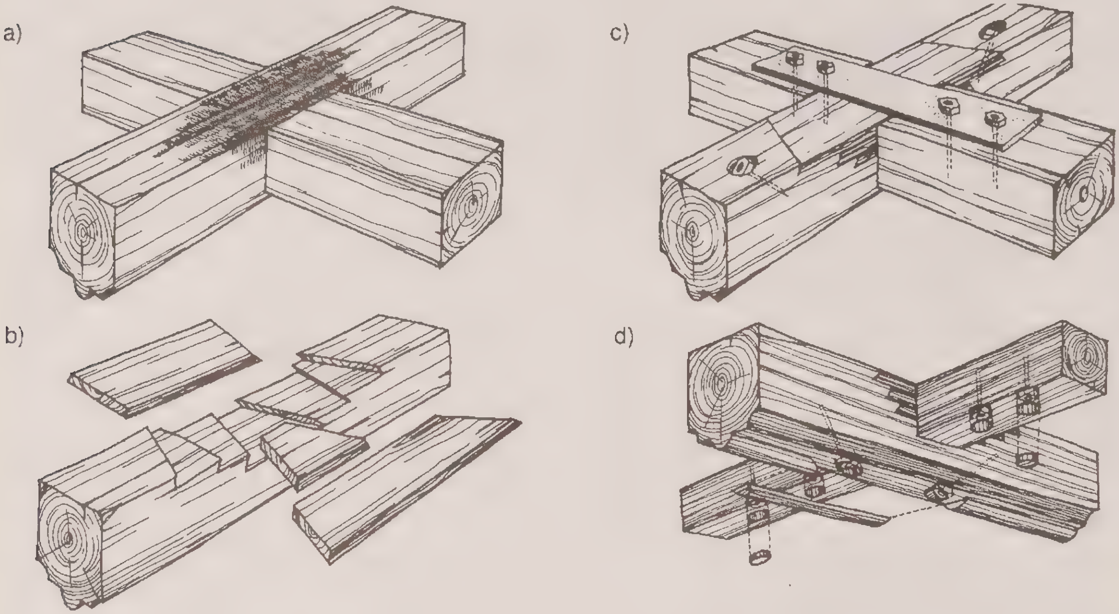

Fig. 14 Lamination repair used to replace a section of a beam.

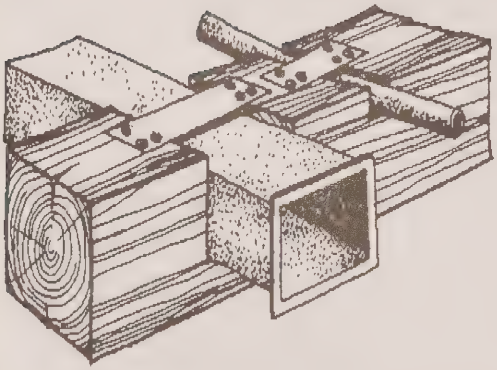

Fig. 15 An external splint bridging a duct and a pipe chase.

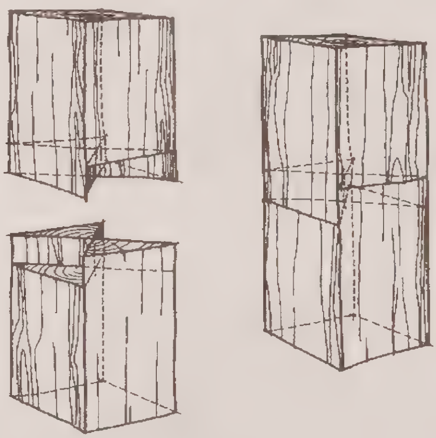

Fig. 16a

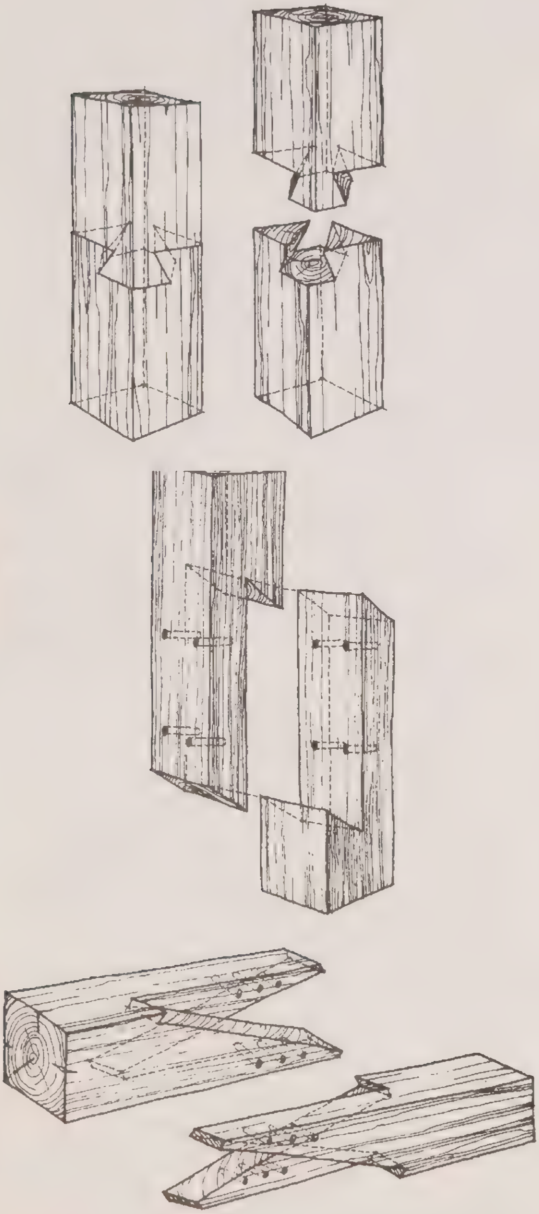

Fig. 16b Scissors scarf and lap scarf with undercut butts are the optimum joints for repair of posts and other structural members subject to compression forces; dovetail and mortise and tenon joints are also used.

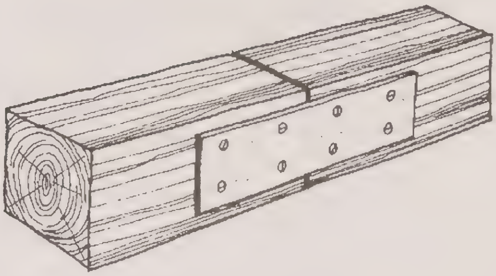

Fig. 17 Sufficient use of gussets or fish plates should allow a simple butt joint in a post or column. It is recommended, however, that the joint transfer at least part of the imposed load.

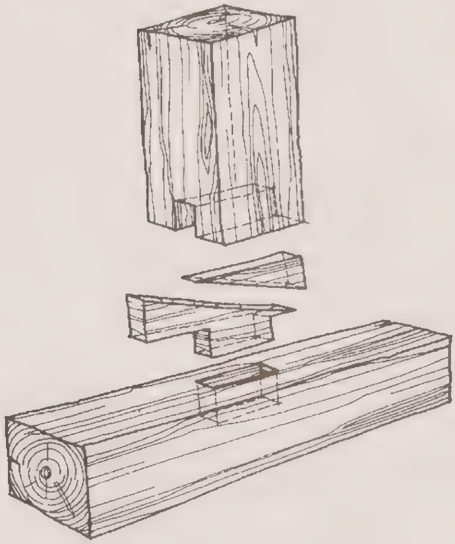

Fig. 18a False tenons

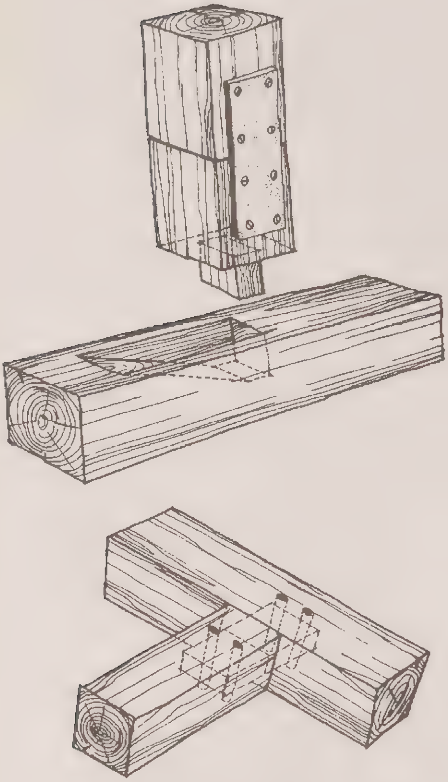

Fig. 18b Techniques by which in situ repairs to posts can be simplified: false tenons (Fig. 18a), wedge tenons, slot mortise.

6.0 REPAIR OF BEAMS, JOINTS AND RAFTERS

Structural members subject to bending stresses can be repaired with joints if the splice is located near the support points or if loads are not excessive. The traditional joints used in these applications are the splayed and tabled scarf with undercut butts, lap scarf with bladed butts and splayed scarf with dovetailed butts (Fig. 19). These are efficient joints, but complicated and therefore expensive to cut. A much cheaper repair is achieved with a lap or scarf joint supplemented with plates (preferably internally) and countersunk and plugged bolts. (Fig. 20). Beams are also repaired by inserting full length fish plates, lamination, inserting tension rods over fractures or chases or by removing internal decay and inserting new wood bedded in an appropriate adhesive (Figs. 14, 21).

a)

b)

c)

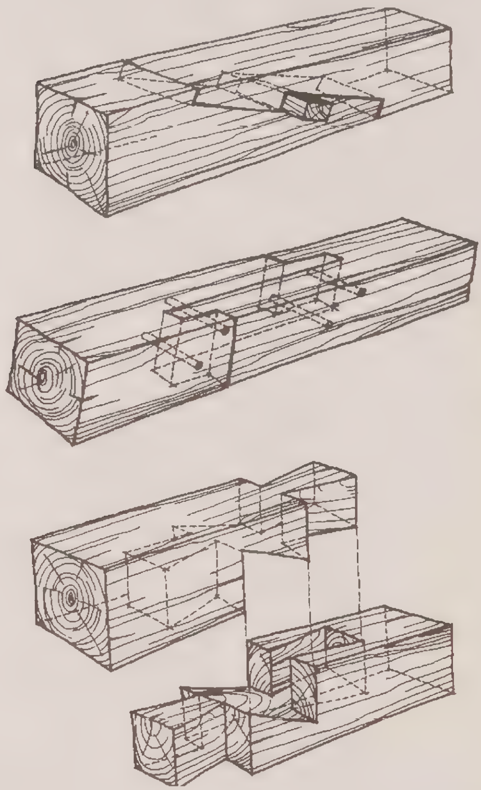

Fig. 19 Several joints suitable for repair of members subject to bending stresses. a) splayed and tabled scarf with undercut butts; b) lap scarf with bladed butts; c) splayed scarf with dovetailed butts.

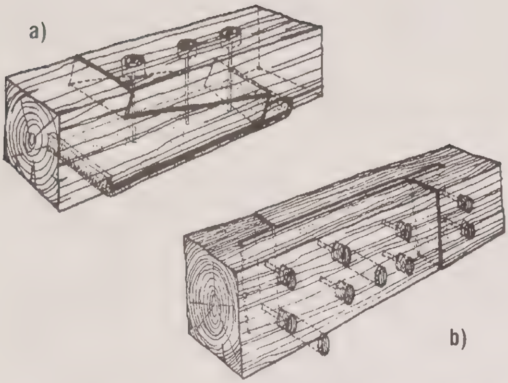

Fig. 20 These joints can be simplified and supplemented with metal accessories to improve their performance. In a) the scarf has bolts and a tension plate added. In b) the joint serves principally to conceal the metal plate which is the true load bearing member.

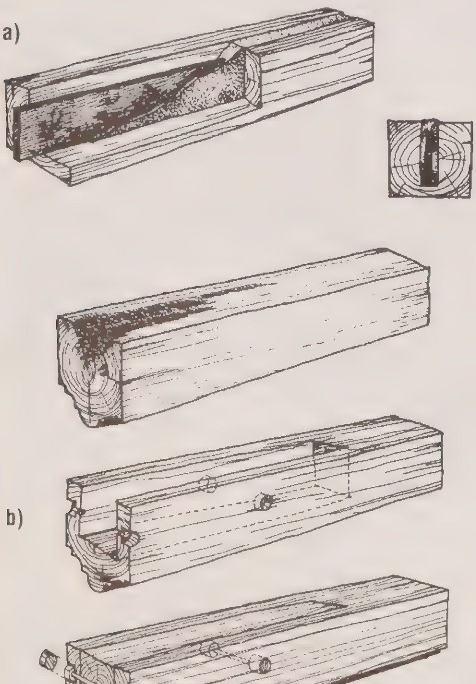

Fig. 21 Beam repair with various types of inserts: a) tension fish plate bedded in epoxy; b) wood inserts bedded in epoxy or other adhesive.

7.0 REPAIR OF TIES AND TENSILE REINFORCEMENT FOR BEAMS

Early carpenters used a number of joints that were capable of transferring tensile stresses.

The most common of these joints are: the dovetail, which is the most popular (Fig. 22); the less efficient table scarf with a wedge (Fig. 22); and the less expensive tusk tenon whose shear strength depends on its pegs and hence is a less desirable joint (Fig. 23).

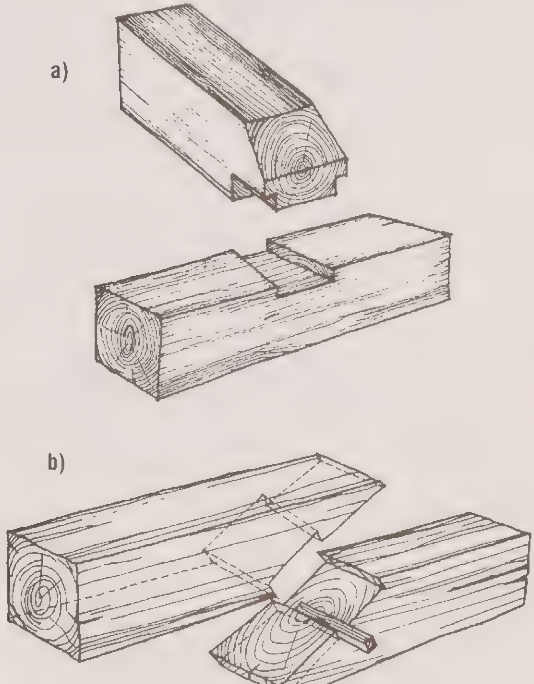

Fig. 22 Joints for repair of structural members subject to tensile stresses a) dovetail b) tabled and splayed scarf with a wedge.

These joints were among the first to be supplemented with iron fittings in the 18th century. Strap bolts were incorporated in mortise and tenon joints subject to withdrawal stresses and this practice continued in heavy timber frame construction until the present day. Tensile reinforcement of members is often achieved by installation of gusset plates, fish plates and tension rods (Fig. 24).

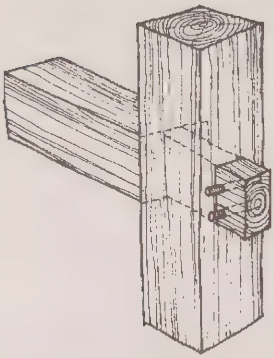

Fig. 23 Tusk tenon is an inexpensive method of transferring tensile stresses to a post but contravenes the traditional principle that pegs are locating devices only and should not be load bearing.

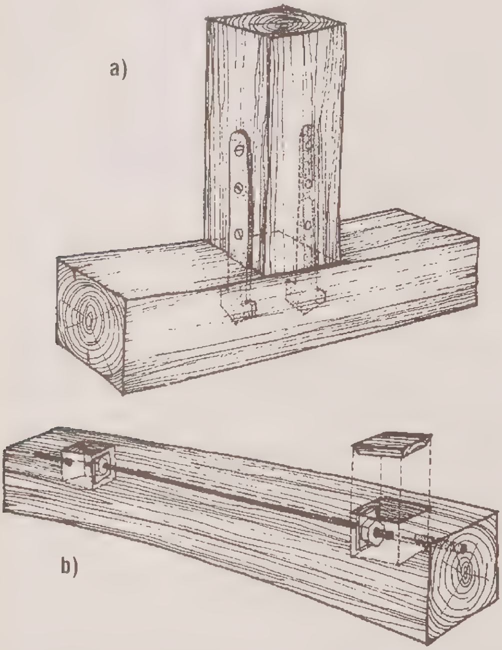

Fig. 24 Tensile reinforcements with a) strap bolts and b) tension rods.

8.0 BEAM END REPAIR

Repair of deteriorated beam ends can be one of the most challenging conservation procedures, particularly if the beam is located in a confined space or in association with a historically significant artifact such as a decorated cornice or ceiling. Although joints such as the splayed and tabled scarf can be used for beam end repair, techniques using metal plates or accessories are usually easier, more efficient, less complex, less

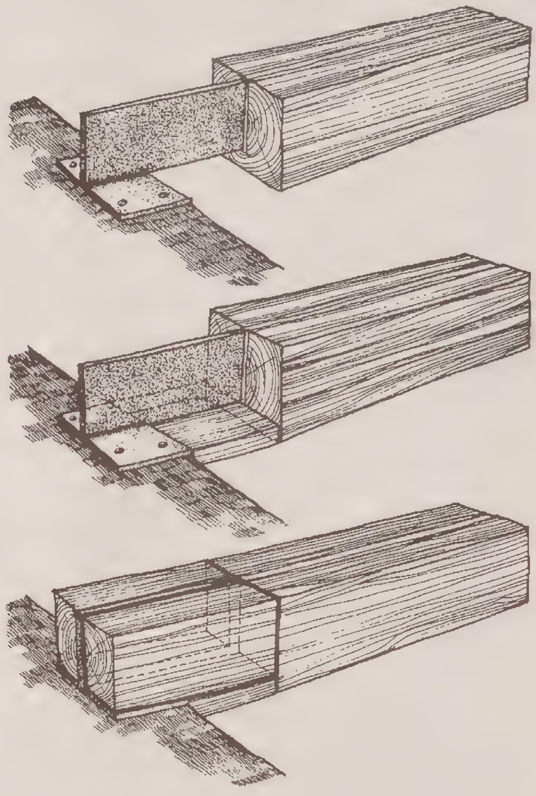

Fig. 25 Fish plate methods

disruptive and with care, can be carried out with minimal visual intrusion. It is particularly important when making these repairs that the condition that caused the deterioration be corrected or avoided. Masonry walls should be damp-proofed and allowed to dry out, beam pockets enlarged to permit ventilation and seats or an impermeable material such as slate or metal

installed in the beam pocket. Adjacent masonry should be sterilized with a fungicide and wood preservative applied to all timber ends which contact masonry. (Figures 25 to 27 illustrate a number of beam end repair techniques).

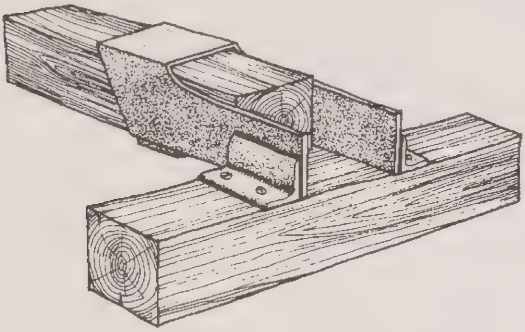

Fig. 26 Beam and cradle

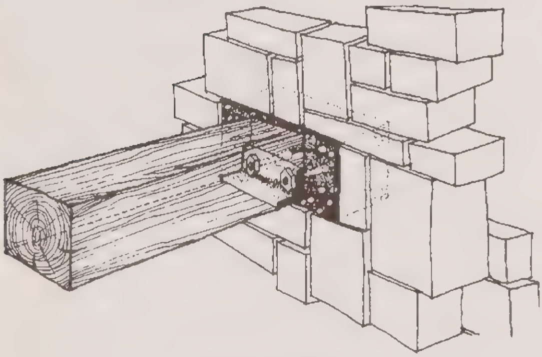

Fig. 27a Hangers

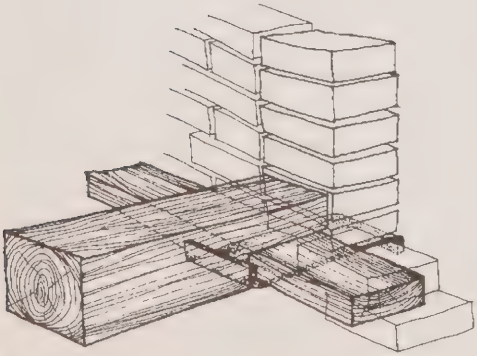

Fig. 27b Ledges

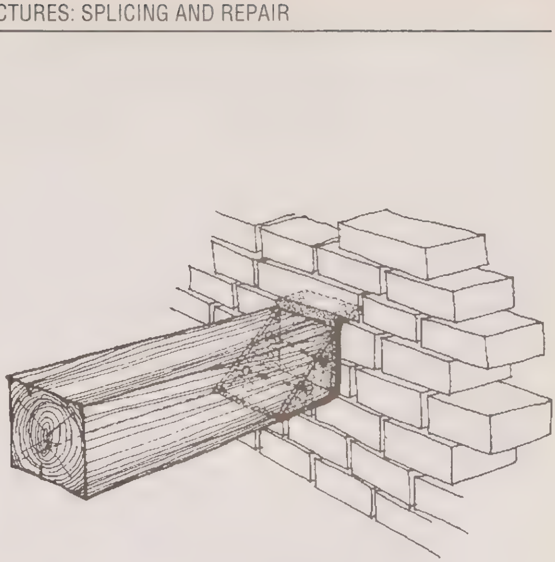

Fig. 27c Brackets

9.0 REPAIR OF JOINTS AND CONNECTIONS

The concealed areas of historic timber joints are prime areas for localized deterioration to occur. Deterioration in joints can be repaired by replacing parts of the joint such as a mortise wall or tenon (Fig. 28). Connections between members can be improved upon by use of special fittings at the joint. For example, split-rings, joist hangers, strap bolts, angle brackets and other structural sections (Fig. 24). Deteriorated timber joints are also repaired with load bearing fillers such as epoxies. The normal procedure is to brace the structure into the desired configuration, cut back all deteriorated wood, construct formwork in the shape of the original timber, insert polyester pins and cast the missing volume in epoxy. However the technique is controversial for several reasons. It is believed that the epoxy/wood interface can act as a trap for moisture and condensation. The major disadvantage of this technique is that the joint loses all flexibility. Alternatively, epoxies can be used to build up the individual decayed members for reworking to the original shape required to form the joint. Specialist literature should be consulted before chemical techniques are considered. Considering the cost and disturbance associated with this technique a more satisfactory result can be achieved by splicing on a new length of timber and cutting a new joint.

Chemical Consolidation: techniques for strengthening historically important timber elements which have disintegrated or become friable from the effects of insect and fungal attack are based on the impregnation of chemical consolidants into the wood. There are a number of options available in this field from waxes to natural and synthetic resins. Specialist literature should be consulted before work of this type is considered. See Section 4.2.1.

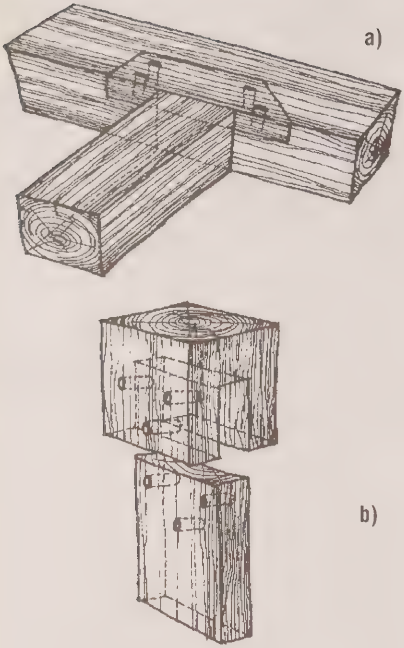

Fig. 28 Two simple repairs to historic joints, a) a replaced mortise wall; and b) a new tenon.

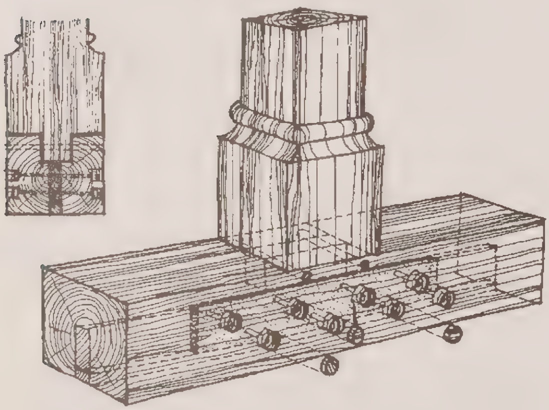

Fig. 29 Strengthening a joint in a fish plate set into a beam across a crack which has formed beneath the mortise.

10.0 REPAIR OF LOG STRUCTURES

The deterioration in log buildings usually occurs in base logs, sleeper beams, top plates and corner notches. Structures built of logs with longitudinal splits, defective chinking or which have been covered with a hard cement render, will be subject to more general decay. Alterations to wall openings made over the building's history may also require reinforcement during restoration.

Replacement of heavily deteriorated base logs involves the techniques of bracing and jacking buildings rather than carpentry. The use of a motorized fork lift for limited lifting and temporary support during replacement has been found useful in some situations. Logs used should be of similar size, species and taper. The corner joint design should be duplicated from the original. Replacement logs to be installed in contact with the ground should be properly protected from decay with a suitable chemical preservative or placed on a properly damp-proofed foundation.

Localized deterioration in base logs and top plates can be selectively repaired by splicing in new material as in frame buildings. The types of joints used in these repairs is less critical than in the repair of frames. Maneuverability and ease of assembly are the principal criteria in the selection of joints. It has been found that the vertical or horizontal lap or the splayed scarf are adequate in most situations. These joints have the advantage that they allow the new material to be inserted from the face of the wall causing relatively little disruption to the structure (Fig. 30).

Extensive repair or replacement of logs usually requires dismantling the building. With adequate bracing a single wall can be removed and the logs renewed by cutting off the log ends, removing the old logs, installing new seasoned logs cut to fit and then replacing the old log ends by blind nailing with spikes. This technique causes the loss of some lateral stability provided by the log end, a factor which must be accommodated by pinning of adjacent logs.

For more information, see Section 7.1 "Special Techniques – Dismantling and Reassembly of Wooden Structures."

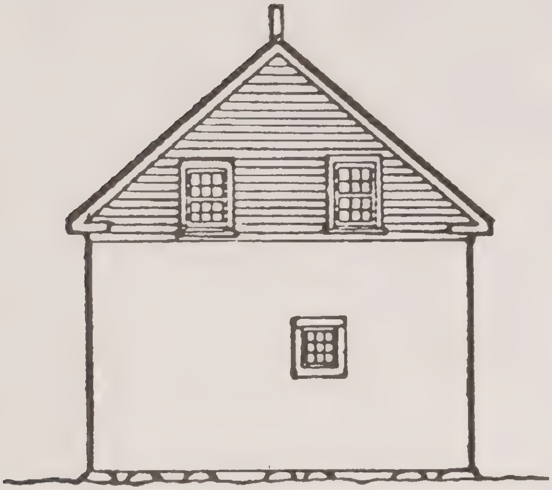

Fig. 30a Red River frame log building

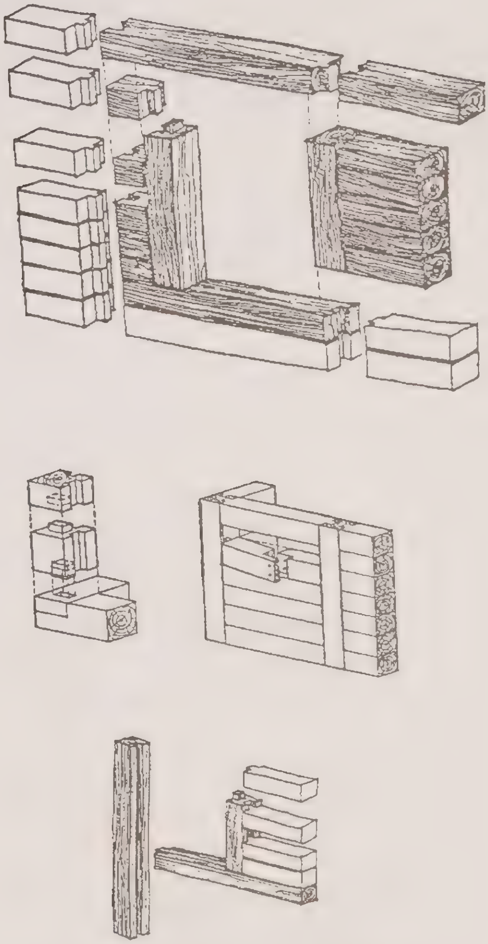

Fig. 30b Replacement of various log components in Red River frame log building (Fig. 30a).

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.2.1

STABILIZATION

WOOD STRUCTURES: CHEMICAL CONSOLIDATION

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

Wood which has been weakened by insects, fungi or mechanical damage can be consolidated with the use of chemicals. Consolidation restores the original dimensional appearance of the wood, fills gaps and enables wood to support its own weight. Consolidation does not necessarily bring about the complete rehabilitation of wood's structural strength.

Consolidation generally involves treatment of a deteriorated material with a substance which penetrates it deeply, improves its mechanical integrity and restores its dimensional stability. The purpose of this report is to guide technical and professional staff in the selection and application of chemical consolidation methods for the stabilization of wood. Consolidants are similar to adhesives which are used to join parts of an object and to protective surface coatings which are used to protect friable surfaces. Adhesives which can be used in suitable solutions to allow impregnation may be employed as consolidants. See Section 4.2 "Splicing and Repair." Consolidation should not be confused with preservation. Fungi will continue to attack the wood unless the decayed material and the source of moisture are removed and a chemical preservative is applied. Insect attack will continue unless an insecticide or fumigant is applied.

1.1 APPROPRIATE TECHNIQUES

The size of a repair, its location (such as interior, exterior, underwater) and the future use of the structure should be taken into consideration when determining an appropriate technique. Review the following criteria when selecting consolidation methods.

a. Costs:
This factor is difficult to evaluate as the cost of the same procedure can vary from project to project. Nevertheless, certain materials and methods are normally costlier than others.

b. Shrinkage:
When a consolidant sets from the liquid to the solid state, shrinkage can occur which will result in contractile forces that are likely to cause distortion in the wood member. The behaviour of a consolidant can be tested by pouring it in the liquid state into a cut-out recess in a plywood frame and allowing it to set. If shrinkage occurs, the frame will become distorted.

c. Structural Integrity:
Poor original detailing and/or changes in use can produce an overload on structural components. Natural disasters (such as fire, wind, earthquake) and chemical attack (such as weathering, high humidity) will affect the serviceability of the material.

d. Appearance:
It is important to determine whether the procedure will harm the historical or aesthetic integrity of the element. The designer should study and evaluate the appearance and type of the member to be repaired, the type of assembly, the physical stresses and the suitability of connectors.

e. Other Factors:
Other considerations should include the degree of sophistication required to effect the repair techniques and whether there are trained craftsmen available to make the repair.

f. Safety:
The degree of risk involved in using the materials should be considered, including determining what protection, bracing or supports are needed and potential hazards to personnel.

2.0 CHEMICAL CONSOLIDANTS

2.1 DRY WOOD

The following consolidants are the most commonly used with dry wood:

a. Waxes:
Waxes are one of the oldest materials used for the consolidation of deteriorated wood. They may be natural (beeswax, paraffin) or semi-synthetic (microcrystalline waxes). Their application requires very favourable environmental conditions and therefore should be done in a laboratory. The principal difficulty with wax is to distribute it evenly into the wood. Brushing molten wax rarely produces adequate penetration. A hot wax bath is required to immerse an entire wooden element.

This is an expensive process, since it requires specialized equipment such as electrically heated baths and lifting tackle for raising and lowering heavy objects. Wax gives only dimensional stabilization and is not totally reversible.

b. Animal Glues:
Animal glues, such as rabbit-skin glue, are properly adhesives, but can also be used as consolidants.

These products generally lose water upon setting and so shrinkage is a common problem.

c. Natural Resins:
Shellac and other natural resins can be used in consolidation, but are not very effective.

d. Synthetic Resins:
Non-solvent types of synthetic resins can be applied as mobile liquids that readily penetrate throughout the wood and solidify in situ at room temperature under the influence of a hardener. These are very useful as consolidants, since they are easy to apply, they are versatile in that setting time can be varied by the choice of hardener, the physical properties of the set resin can be varied by the choice of resin or by the addition of a plasticizer and many do not cause shrinkage or distortion because no volatile material is involved.

Among the many kinds of synthetic resins used in conservation work, polyester resins, polyacrylate resins, epoxy resins, polyvinyl acetals, (including polyvinyl butyrals), acrylates and soluble nylons are the most commonly used. Of these, epoxy resins are the most versatile and the most useful for architectural conservation because of their bonding with all kinds of surfaces, the variety of forms in which they are available, the absence of appreciable shrinkage and their ability to set at room temperature. Epoxy resins provide structural stability as well as dimensional stability. They are durable and resist cracking and chemical attack. They can be mixed with sawdust and applied as a plastic material to build up a deteriorated surface.

e. Wood Epoxy Reinforcement (WER) System:
This system provides structural stabilization rather than dimensional stabilization and hence is not truly a consolidation technique. Nevertheless it is often used in the same circumstances as consolidants.

The WER system's advantages are that it has minimal visual interference with the artistic value of a wooden element. It avoids expensive and undesirable replacement. Epoxies cure in a few days to give increased structural strength.

Epoxy is suitable to repair end splits, interior longitudinal splits, broken members and decayed wood. It penetrates the wood fibres and connects the desiccated wood into a material with different properties from those of natural wood. All rotten matter should be removed by drilling or coring. Epoxies will bond only to sound wood.
Glass fiber rods, aluminum plates and steel plates can be inserted to reinforce the epoxies and provide increased structural strength.

f. Xylamon:
This product, which is imported from West Germany, has consolidative effects similar to wax. The application process is more successful than wax because Xylamon remains in a liquid state until it has been impregnated in the wood, where it solidifies. It should be applied with a small funnel or syringe.

2.1.1 Evaluation

Most of these substances have been introduced quite recently and professionals are still evaluating their relative merits. In a paper prepared by David W. Grattan of the Canadian Conservation Institute, titled *Consolidants for Degraded and Damaged Wood*, various brands of consolidants were tested and compared. Conclusions were as follows:

a. Xylamon LX hardening cannot be recommended because it is much too mysterious in terms of its nature and aging properties. It does not seem to be much better than anything else as a consolidant. (It is definitely not butyl methacrylate as is rumoured in some conservation circles.)
b. AYAC would be a third choice as a consolidant. AYAC can have very concentrated solutions with low viscosities; it dissolves in non-toxic alcohols and is stable but has a low glass transition temperature.
c. Second choices are Acryloids© B72 and B67. B72 has excellent stability, but is very soft and must be used in toxic solvents. B67 can be obtained in less toxic mineral spirits but may be less stable than B72. One of the other problems with the Acryloids© is that much data concerning their mechanical properties has not been published
d. Polyvinyl butyrals seem to offer the best combination of properties. Their mechanical strength, flexibility, stability and solubility in non-toxic alcohols renders them very useful materials. Their principal disadvantage is their high viscosity in solutions.

2.2 WATERLOGGED WOOD

Wood which has been submerged in water for many years presents special conservation problems. Its cell cavities become filled with water and cell walls are weakened by a slow chemical reaction known as hydrolysis. When the wood object is dried, the cells change size and shape. Capillary tension caused by the pressure differential during evaporation may cause the cell walls to collapse. Desorption caused by the removal of water within the molecules of the cell wall can cause shrinkage.

Additional stresses develop and severe dimensional instability (usually seen as checking) occurs. Architectural conservators encounter waterlogged wood in archaeological excavations in frozen or wet lands and in the conservation of below-grade woodwork. The consolidation of waterlogged wood is a time-consuming laboratory process that involves controlled drying (freeze-drying and drying in sand have been tried) and impregnation with consolidants, such as:

a. Polyethylene Glycol:
This synthetic wax, known by the trade names PEG and Carbowax, replaces the water in waterlogged wood in a manner that prevents deformation and provides mechanical stability. Polyethylene glycol is available in a variety of consistencies and concentrations and can be applied as a spray or a paste.

b. Tetraethoxysilane (TEOS):
Waterlogged wood has been immersed in a TEOS bath on an experimental basis in Denmark. Initial results were not good; the wood became discoloured and spongy and light in weight.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.2.2

STABILIZATION

WOOD STRUCTURES: CHINKING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
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ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

In log buildings, the individual logs are usually separated by a crack, called a "chink." Chinks allow for movement and warping in the logs and they also accommodate irregularities in the shape of the logs. They may be as narrow as one or two cm or as wide as ten cm or more. The chinks are generally filled with a material or combination of materials. "Chinking" is the name given to both the process of filling the interstices and to the filler material(s) used.

1.1 PURPOSE

The purpose of chinking is to fill the chink space between logs. The chinks expand and contract at varying rates because of changes in temperature and humidity and sag from the instability of the wood. As well as contributing to the airtightness of log buildings, chinking should attempt to accommodate these movements to some extent.

1.2 REPLACEMENT VS. STABILIZATION

Chinking has always been considered to be a temporary measure to fill the interstices. It requires renewal and replacement on a periodic basis. Consequently when faced with the stabilization of a log building, the complete replacement of the chinking is often required. Chinking itself is usually not stabilized (See also Section 3.1.).

2.0 MATERIALS

Chinking may be composed of several distinct materials. If the chinks are large, a filler may be inserted into the spaces. Filler materials may be rigid or soft and include wood, masonry and soft organic materials. The filler is then usually covered with a daubing material both inside and out. The daubing is a mortar, plaster- or clay-like substance, often mixed with a binder that is applied in a wet state and allowed to dry. Another substance is occasionally added to the daubing as reinforcement.

Chinking

2.1 FILLERS

Several kinds of filler are found in chinked structures. Some of the more common types are:

2.1.1 Rigid Fillers (or blocking)

a. Some fillers are wedged, usually at a slant, into the interstices. If these are made of green wood they can be driven deeply and will take on the shape of the chink to some extent. They form a key for the daubing as well as filling the cracks.
b. Blocks of wood – perhaps mill ends, are used for larger chinks.
c. Split or riven boards are nailed horizontally to the exterior or interior wall to cover the cracks. This is a kind of wood siding and was common in the U.S. deep south. Small branches, twigs or bark might be used.
e. Small stones can be used to fill the chinks.
f. Hewn stones, held in place with mortar are occasionally found in structures with very wide chinks.
g. Bricks and fragments of bricks are also used as fillers.
h. Plaster or mortar are used, which may be the same formula or different from the daubing.

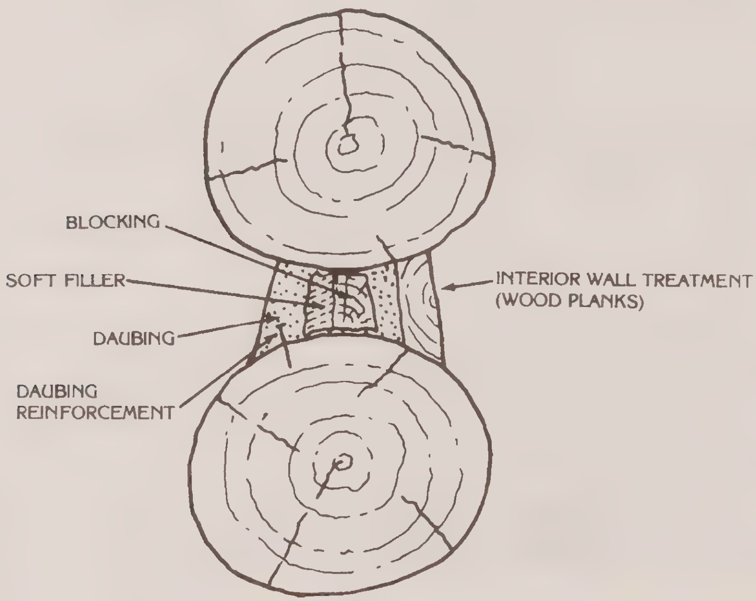
2.1.2 Soft Fillers

Soft fillers may be used alone or together with rigid fillers to fill small cracks, allow log movement, increase insulation value and/or provide a surface to which the daubing will adhere. Materials may include:

a. oakum, which is a fibrous material made by untwisting old jute or hemp rope and which is sometimes oiled. It is used for caulking as well in other than log buildings and in ships. It is pliable, a good insulator, resists decay and repels insects and rodents;
b. rags, burlap or other cloth materials;
c. moss was readily available and often used as a filler;
d. straw or paper was sometimes inserted into the chinks; and
e. fiberglass insulation (or rigid styrofoam) is used in modern log buildings, but obviously not in earlier generations.

2.2 DAUBING

Daubing is the final seal which covers the filler and closes all remaining cracks or crevices. Sometimes it is used without a filler if the chinks are small. The following are the most common ingredients; virtually any mixture made from these is possible.



Cross Section of Chink Area
H. Goodall and R. Friedman. Log Structures: Preservation and Problem Solving, *p. 103*

a. Mud or Clay:
Taken from the ground and used directly as a daubing material, often mixed with a binder of animal hair or straw. The daubing dries to a hard finish, but it is brittle and absorbent and will shrink in time. The application of mud or clay was called *bousiller* by Québécois and Métis.

b. Lime or Cement:
Moistened and used in combination with sand or another binder, lime, cement or mortar mix, are common daubing materials. Lime is soft and absorbent and shrinks. It retards infestation by insects and rodents. Portland cement is hard and brittle and can crack and pull away from the logs as it dries or can adhere and damage the logs.

c. Animal Dung:
This readily available material has found application as daubing. It is a flexible and absorbent material that decomposes in time.

d. Binders:
Various building materials are used in daubing. Animal hair, straw and sand have been mentioned. Others include ashes, salt, sawdust, flour and shredded newspaper. Each has its particular characteristics.

e. Daubing Reinforcement:
Metallic materials such as galvanized nails or staples are sometimes used as reinforcement. If the filler does not provide an adequate key for the daubing, chicken wire or metal lath screen may have been applied as a key in more recent chinking.

3.0 RENEWAL TECHNIQUES

3.1 GENERAL REMARKS

As mentioned in Section 1.2, chinking is inherently a temporary process. Chinking provides a sacrificial finish which is abraded and eroded by the weather. It regularly requires renewal or replacement; stabilization (in the sense in which other materials are stabilized) is usually not an appropriate intervention.

Because of this process of continual renewal (the Métis of Saskatchewan might redaub their log houses every year or two) with no assurance that the same material is used every time, the extant chinking is likely different from the original chinking. The periodic nature of redaubing likely means that a building will have a variety of textures, colours or techniques.

This patchwork look is "authentic." Only when the structure was first daubed or is totally redaubed, does it have a uniform appearance.

3.2 ANALYSIS

Samples of the daubing and filler should be recorded and then analysed (if necessary, in the laboratory) to determine their composition. The investigator should estimate the relative age of the various samples and the amount of chinking which requires renewal. Researchers may compare the information with data concerning similar structures.

3.3 DESIGN

The design team will address the question of what appearance is desired: whether the chinking should be uniform or varied and whether it should attempt to restore the appearance to a particular date or period. Cracked daubing must be removed and replaced; stable daubing can be retained. The design team will decide what should be conserved and what replaced.

The new daubing can attempt to reproduce the original mixture or can use a more stable compound that imitates the original appearance. Colourants or different binders can be used to match the colour of the existing or an earlier daubing. Test samples of different formulas should be applied and allowed to dry, in order to check for colour, cracking, shrinking and bending.

Another design issue is whether to restore the original or extant filler or whether to insert a new material that will provide better energy efficiency (e.g. rigid or soft insulation), a better key for the daubing or a more stable substance.

3.4 REPLACEMENT AND REPAIR

Quoted from H. Goodall and R. Friedman's *Log Structures*, the following may be useful as a basis for model specification.

> A Chinking Method
> The following technique for replacing and repairing chinking can be used with most formulas. Not all of the steps are necessary in every method and not every chinking contains a filler, a blocking and a reinforcement. Often only the outer layer of daubing needs

replacement; the rest may be in good condition. Be certain to finish all work that will cause movement in the walls before beginning the chinking; that includes renailing the trim (p. 108).

Preparation
1. Remove all loose, broken, spalled and cracked daubing. Since patching is always noticeable and usually cracks at the joint line, it may be better to remove whole lengths of the old material than several short sections.
2. Clean the area by brushing away the dust and debris between the logs. This may require scraping or wire brushing.
Blocking
3. Repair or replace missing or deteriorated blocking material. Be sure it is securely nailed between the logs.

Wood Chinking
1. Remove all bark.
2. Replace wood chinking with either green or seasoned wood. If green, the chinking is likely to be more flexible and to fit the contour of the chink area, but it will shrink within a few months and will probably require renailing. In a good chinking job, the wood will be tight against the logs and will blend with the ends of adjoining chinking....

Soft filler materials
4. Using a thin slat of wood to drive the soft filler – oakum, fibreglass insulation, rope – securely between the logs or between the wood blocking....

Daubing Support
Although most original daubing was not reinforced, seriously consider adding reinforcements to the new daubing. If put in correctly, the reinforcement will not be seen but it will help anchor the daubing.

5. If there is original reinforcement such as nails, staples or wire mesh, duplicate it, unless it has not been satisfactory.

6. Acceptable reinforcements are:
- Split or sawn wood strips, $^1/_4$ inch by $^3/_4$ inch, nailed along the lower log of the chink area. The strips or cleats are usually 12 inches to 36 inches long. If working on an authentic historic restoration, this method should not be used unless it was used originally.
- Galvanized, coated or ringed nails with large heads (roofing or box nails) driven every 2 to 5 inches into the daubing area and into the lower log. Nail heads should be at least a half-inch below the daubing surface to prevent cracking and rust stains.
- Galvanized wire lath or chicken-wire attached to the logs and converted with at least a half-inch of daubing. Rusting and cracking are common problems with this method, so be certain to cover the wire with *at least* a half-inch of daubing.

Daubing
Daubing should not be done in the hot sun, when the logs are hot from the sun or when the temperature is expected to drop below freezing. Under extreme conditions of either hot or cold, the daubing will dry out, crack, shrink or pull away from the logs.

7. Obtain daubing tools:
- A mortarboard or hawk.
- A small mason's trowel, which is easier to use if it is ground or cut narrower, to match the width of the daubing.

8. Premix the dry ingredients in a wheelbarrow or on a large surface, such as a piece of plywood. Gradually add water until the consistency is like stiff mashed potatoes. Mix thoroughly. If the mixture is too wet, it will droop or fall out; if it is too dry, it will be difficult to press into the logs and to smooth out. In either case, it will not stick (pp. 109-10).

9. Mix only enough daubing to be used in thirty minutes; daubing dries out quickly and becomes unworkable. If the daubing begins to set up, do not add large amounts of water; that merely reduces the daubing's strength and makes it brittle. Either use the mixture quickly or throw it out and make less the next time.

10. Check to be sure that all reinforcing materials and fillers are properly attached. Once the daubing has been applied, renailing the reinforcing materials may make the logs vibrate and loosen the new daubing.

11. Immediately before applying the daubing, spray the filler material and the logs with water. This helps prevent moisture from being withdrawn from the daubing mixture and helps reduce cracking and shrinkage during drying.

12. Place the hawk immediately below the space to be filled and push the daubing between the logs.

13. With the trowel, work the daubing into the filler and/or blocking, pushing on it to get rid of air pockets and to press it around the reinforcing material, filler and/or blocking.

14. Spread the mixture along the length of the chink area, using a continuous motion. Overlapping will cause cracks and scaling. Work it until it is about an inch to an inch and a half thick. Be sure nail heads, wire, and filler materials are covered with at least a half-inch of daubing. The angle of the daubing is very important. If water can run around the log and into the daubing, the log will eventually decay. Angle the daubing surface in at the top of the chink area, instead of making it vertical... (pp. 109 - 11).

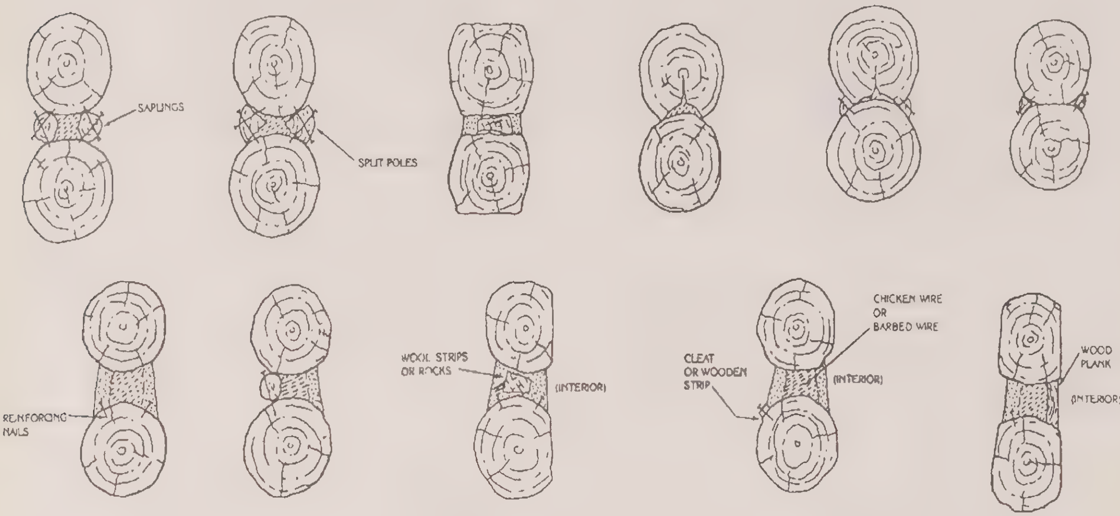
15. Smooth the surface of the chinking and trowel it until slightly wet; this makes it more resistant to the weather.
Note: Wide or deep spaces may need two or three layers of daubing. If large spaces are filled in one layer, the daubing will droop. For good adhesion, scratch the first layer of new daubing and allow to set up before applying the second. The second or finish layer should be at least three-quarters of an inch to an inch thick.

16. If the daubing droops (due to over-troweling or to a mixture that is too wet or too thick), retrowel it in about a half-hour, after it has begun to set up or become leather-hard.

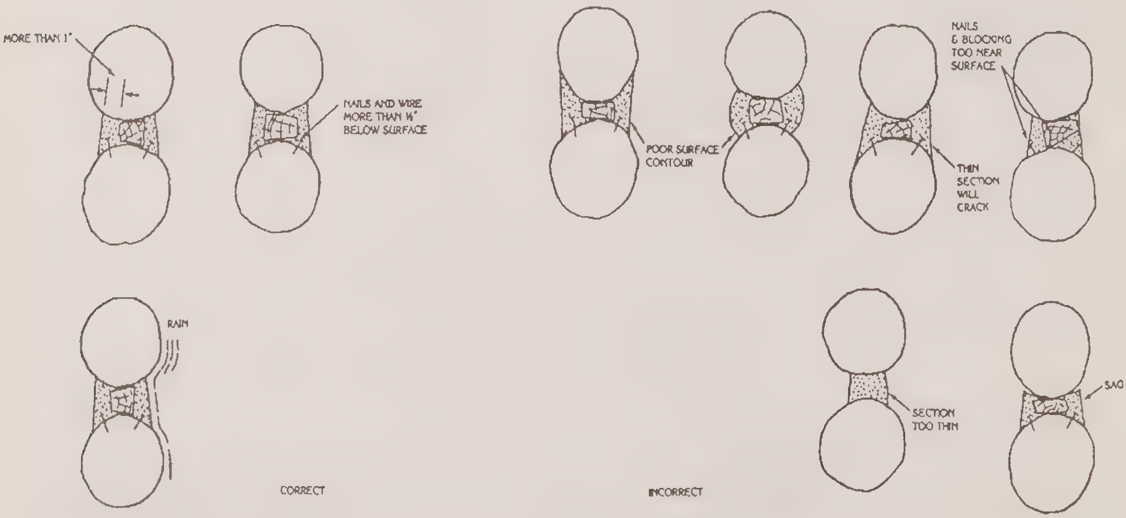
17. Daubing that is applied smoothly should not show trowel marks. If it does, remove them with a wet trowel, a balled cloth, a wet whitewash brush or a whisk broom while the daubing is still "green" (before it completely sets).

18. Original daubing that shows tool marks should be duplicated as closely as possible. After the daubing is hard, clean or scrub the logs with a wire or nylon brush, being careful not to damage the log or scratch the daubing surface (pp. 111 - 12).

4.0 ILLUSTRATIONS



Chinking and Daubing Techniques
H. Goodall and R. Friedman. Log Structures: Preservation and Problem Solving, *p. 104*



Correct and Incorrect Daubing Techniques
H. Goodall and R. Friedman. Log Structures: Preservation and Problem Solving, *p. 113*

COMMONLY USED DAUBING TECHNIQUES
Mix All Formulations With Potable Water

	parts (volume)	material		parts (volume)	material
#1	1	Portland cement	#2	1	lime
	2	masonry cement		4	sand
	3	sawdust			
	4	fibered plaster			
#3	1	Portland cement	#4	1	Portland cement
	4 – 8	lime		3	lime
	7 – 10	sand		5	sand
#5	1	Portland cement	#6	1	mortar cement
	1	lime		2	lime
	3	sand		3	sand
#7	6	clay	#8	4	wood chips
	2	wood ashes		2	lime
	1	salt		8	sand
				parts (weight)	
#9	1/4	cement	#10	1	Portland cement
(Hutslar)*	1	lime		4	lime
	4	sand		12	fine white sand
	1/8	dry color		approximately	
		hog bristles		.05 lbs. of animal	
		or excelsior		hair added per	
				hundred lbs. of mortar	
#11	1	white cement	#12	6	sand
	5 – 8	lime or lime putty		4	lime
	7 – 10	sand		1	cement

"A representative sampling of daubing formulas. Although cracking and shrinking are always a problem, we have had the most success with #3, 9 and 12." Harrison Goodall and Renée Friedman. *Log Structures: Preservation and Problem Solving*, p. 107.

*Source: Donald A. Hutslar. "Log Cabin Restoration: Guidelines for the Historical Society." American Association for State and Local History, Technical Leaflet No. 74, *History News*, Vol. 29, No. 5 (May 1974), Nashville.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.3

STABILIZATION

IRON AND STEEL STRUCTURES

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ORIGINAL DRAFT: A. WILDSMITH

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1.0 INTRODUCTION

This article assumes that the historic structure does not require stabilization due to over-stress and that temporary stabilization has been executed. With this noted, there are five other basic types of deterioration to be considered when dealing with historic stuctures of iron and steel. These are: corrosion, abrasion, loosening of connections, fatigue and impact.

The purpose of this article is to provide guidance and instruction to technical and professional personnel who are charged with the stabilization of historic iron and steel structures. The scope depends on the limits imposed by the project schedule and expertise involved.

1.1 DEFINITIONS

a. A structure is an assembly comprised of interdependent and interrelated parts in a definite pattern or organization. It is often an engineered project large in scale, though it may also be a component, such as a roof framework.
b. Stabilization involves the application of techniques designed to preserve and consolidate existing historic fabric for an extended period, as part of site development. Techniques may include the use of chemical preservatives, cleaning agents and coatings, the upgrading of environmental controls, internal and external structural bracing and reinforcement and limited replacement and splicing of badly deteriorated areas. Dismantling and reassembly can also be included to the extent that it is applied to only a portion of the work and that the historic material is treated and reused in its original context.

2.0 PREPARING FOR THE STABILIZATION

2.1 TERMS OF REFERENCE

Take the following steps when preparing the terms of reference for the stabilization task:

a. Define clearly the objectives of the stabilization;
b. Identify issues and constraints which are particular to the historic structure and which will affect the stabilization. These issues may include the historical, architectural and technical significance of the structure, the type and degree of anticipated modification, its complexity, the constraints of schedule and budget and the availability of supplementary information; and
c. Establish clear working relationships between the project manager, technical specialists, in-house personnel, consultants and others who may be involved in the project.

2.2 BACKGROUND PROJECT INFORMATION

Gather existing documentation relevant to the structure. Assemble this information in collaboration with the historian and other members of the project team. The documentation should include all historical and contemporary records which will contribute to an understanding of the structure's evolution, recent investigation, temporary protective measures, maintenance and present status.

2.3 STRUCTURAL FINDINGS

The technical person responsible for the stabilization work should examine the superficial and underlying parts of the historic structure and make note of where problems exist and the type and extent of deterioration, before deciding details of procedure and schedule. Take note of any work which would require the assistance of technical specialists. Defects such as corrosion of iron and steel occur principally in difficult-to-access locations of historic stuctures. Maintenance, including repainting, is often neglected in these areas. Abrasion (erosion) of iron and steel sections is identified by worn, smooth surfaces. Abrasion of iron and steel elements and components is associated with the working of moving parts in contact.

Rivets and bolts in connections are sometimes subject to shock or impact loading and tend to become slack with time. Loosening of the connections causes slippage in the joints, distortion of the supporting framework and increases the vulnerability of the framework to fatigue failure.

Fatigue may be defined as the fracture of a structural member due to a repetitive, fluctuating load occurring at stresses at or below usual allowable design values.

Exposed iron or steel sections are sensitive to damage from the impact of moving objects. Impact damage is characterized by local distortion of the affected members, usually in the form of a crimp or a bow.

Corrosion

Impact

Loosening

2.4 SAFETY AND SECURITY

The person charged with the stabilization must consider provisions and problems of security, including personnel and material hazards and see that sufficient resources to fight a fire are on site or nearby.

2.5 TESTING

Where, due to live load, dead load, impact or other reasons, the supporting framework may fail, then its structural strength and load bearing capacity should be tested. This can be done by calculation, by visual check for concealed cracks or other damage or by arranging for load tests.

3.0 STABILIZATION

One objective of stabilization is the protection of historic fabric through the prevention of decay. The other objective is to impart structural strength where collapse of the framework is threatened. As much as possible of the original form and detailing should be preserved.

The execution of the stabilization work should include the following:

a. Unless there are initial coatings of particular value, all iron and steel components should be cleaned to remove loose paint, rust and scale by light grinding, sanding, wire brushing, scraping or using chemical paint removers. Heat plates and heat guns may be used to remove paint if this can be done without causing deformation or damage to the iron and steel. For areas of exposed or decorative metalwork, test panels in inconspicuous areas should be prepared for approval.

b. Where abrasion or corrosion are localized in a member or portions of a member of the supporting framework and collapse is imminent, compensate for the loss of section by "sistering" new metal across the area of deterioration. This is accomplished by taking plate or rolled sections, running them alongside and past the deteriorated portion of the member and fastening them to the supporting framework in areas where the framework is sound.

c. This method is also called "plating" and is convenient for stabilizing members which have cracked, buckled or suffered local crushing. This technique may not be suitable where the appearance of additional plates would be detrimental to the restoration. If such is the case, use of a replacement member or a hidden bracing to remove live load from the damaged member, may be required. Before installation of the plates, the contact surfaces between the new and existing members should be clean and dry and the whole assemblage cleaned and coated after plating. Where connections have deteriorated, they may be stabilized by plating or replacement.

d. Where only the fasteners are deficient or deteriorated, they may be replaced by reaming out the holes and inserting stronger fasteners such as high-strength bolts. Where the connections are merely loose, if bolted, the bolts should be tightened to the allowable stresses using appropriate torque wrenches. Occasionally bolts or rivets which work loose should be replaced.

e. Watch for corrosion of the main structural material under the rivets, nuts and washers. Where this occurs it may be necessary to ream or drill the corroded material away from around the hole and install oversize bolts, rivets and washers.

f. Corrosion between angles or channels placed back to back is a relatively common problem. If the loss of material is not so severe that strengthening is required, further problems can be prevented by making sure that all rust and scale are removed and by seal welding to prevent the intrusion of moisture.

g. Localized corrosion of angles and channels used back to back is a very common problem on steel stringer bridges. Also, on components of bridges (especially bearing surfaces and expansion joints) after years of exposure, the machine-finished contacts are severely pitted by corrosion. This problem can be corrected by removing the plates, re-machining the surfaces and reinstalling. Use shim plates to make up loss of thickness.

h. Whenever an iron or steel structure is stabilized, clean all existing surfaces and give all new and existing surfaces a suitable protective coating of primer, paint or other material. The philosophy is that if there has already been trouble with the historic structure to the extent that stabilization is required, more trouble is likely to occur and that it is worthwhile giving both the new and existing metal a good protective paint finish. In repainting, the person charged with the task should be sure that the new paint is compatible with the existing paint and that the old coating is "spot primed" before applying the new. Paint may be applied by brush, spray or roller.

3.1 FINAL REPORT

The person responsible for the stabilization work should ensure that the structure is documented with both photographs and measured drawings, before and after stabilization. Save samples of all discarded material. The analysis of decayed material could be important for documenting the history of the structure.

4.0 MAINTENANCE

A maintenance program is a pre-determined set of maintenance routines performed by a contractor or in-house personnel on a routine basis. Maintenance tasks are required for a stabilized structure to avoid deterioration and provide for public safety and security. Reference Vol. V.1 "The Preparation of Maintenance Manuals."

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.4

STABILIZATION

WINDOWS AND DOORS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

Windows and doors are designed for movement; therefore they are very susceptible to mechanical wear. The openings for windows and doors interrupt the overall cladding system of the building and introduce danger points where moisture can penetrate the wall and significant air leakage can occur. Any attempts to prevent the penetration of moisture and the flow of air creates additional joints and ledges which may themselves in turn be susceptible to moisture penetration and air movement. Consequently windows and doors represent relatively weak points in the building envelope.

This section cites techniques of stabilization for windows and doors, treated according to the material.

Deteriorating Window

2.0 WOOD WINDOWS

2.1 LOOSENING STUCK WINDOWS

Wooden windows generally become stuck as a result of being coated with either too much or too little paint.

a. If a window is painted shut, tap the sash frame, taking care not to damage the wood surface. Run a putty knife between the sash and window frame to break the surface seal. Place a wide flat "jimmy" bar directly under the stiles and pry up. This will prevent possible damage to the sash tenons. While the use of one bar under one stile may be effective, the use of two bars, one placed under each of the stiles and pried simultaneously, will prevent possible distortion of the frame. If the window cannot be loosened this way, repeat the tapping of the frame to break any remaining seal.

   If the sash remains stuck, then remove the inside stop and remove the sash. If the window has counter-balanced weights, the sash cords should be tied before being freed from the sash.

   When the sash is removed, clean off excess paint and clean the guide channel, rub a lubricant such as the butt end of a paraffin wax candle on the wood surfaces. If the wood is found to be uncoated when the sash has been removed, seal the wood with primer-sealer or with a penetrating oil such as tung oil before the wax is rubbed on.

b. Swelling caused by the wood not being sealed with paint or other protective coating, can also make windows stick. The sash should be removed and treated as described below.

2.2 DIMENSIONAL CHANGES

Wood windows are subject to shrinkage or expansion through changes in temperature and in moisture levels in the wood. These dimensional changes can cause problems.

2.2.1 Preventing Moisture Absorption

Wood must be sealed to prevent moisture absorption. Paint should be applied to all surfaces which may come into contact with water, in particular the exposed end grain of wood.

When wood has been weathered and paint is peeling due to moisture in the wood, the first step should be the removal of all the remaining paint. This will increase the amount of water repellent which can be absorbed, as well as improving the adhesion of new paint. A good recipe for repellent is one-half boiled linseed oil and one-half turpentine. Commercial

repellents or water sealers are also available. They should be applied generously, particularly at joints, for maximum absorption. Repeat the coverage after the first coat has dried. Any remaining "open" joints should be caulked with a polyurethane-based sealer.

After the water repellent has dried, apply an alkyd primer followed by a finish coat of alkyd or latex paint, allowing time for each coat to dry thoroughly.

2.3 CONSOLIDATION

Wood which has suffered a significant amount of rot or other deterioration to the point where dimensional or structural stability has been weakened should be consolidated. Consolidation is discussed in Section 4.2.1 "Chemical Consolidation." Epoxy resins are usually indicated in windows. An epoxy of thin viscosity can be applied with a brush. It is best applied on a horizontal surface to aid penetration. Once the wood has been impregnated and epoxy has cured, use an epoxy with a thick viscosity to fill cracks in order to establish a relatively smooth surface for painting.

3.0 REGLAZING SASHES

If glass has been removed from a window sash for replacement or if existing windows need reputtying, the following procedures may be followed for reglazing.

3.1 REMOVING PUTTY

Loose and crumbling putty should be completely removed before new putty is applied. Most putty which has deteriorated should be easily removable. When putty cannot be removed easily, the use of heat or alkalies should be considered.

3.1.1 Alkalies

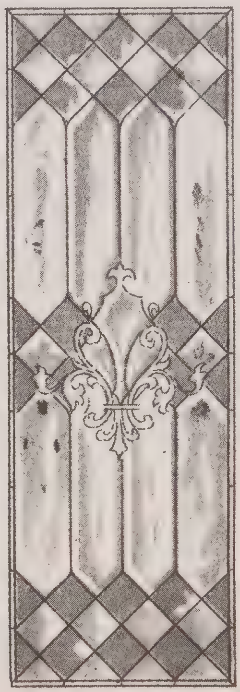
Alkalies chemically break down the binder of the linseed oil in the putty. Some possible alkaline materials which may be used are lye, trisodiumphosphate and potassium carbonate slaked together with quick lime in a 1-to-3 ratio by weight. These chemicals should be applied in a paste form directly to the putty and must be constantly dampened until the putty softens.

The alkalies also have certain disadvantages:

a. wet alkaline paste will raise wood grain;
b. alkali must be flushed off with water and the wood neutralized with a weak acid; and
c. precautions must be taken to prevent inhalation of alkaline dust and so protective clothing, goggles and gloves should be worn.

3.1.2 Heat

Heat can be applied to soften putty, but control of the heat source is very difficult to achieve. This means that there is a high possibility of glass breakage due to rapid temperature differences between the two glass surfaces. The possibility of breakage may be reduced by increasing the temperature of both sides of a glass pane with heat lamps. When the putty is ready to be heated, turn off the heat lamp on that side and apply a heat shield sheet over the pane. Breakage is still possible with this method.



Stained Glass
Courtesy of Lee Valley Tools Ltd., Ottawa.

3.2 PUTTYING

When all of the old putty – or as much as is easily lifted – has been removed, apply a solution of one-half linseed oil and one-half paint thinner or turpentine to the wooden seats and allow to dry before laying a new bed of putty. This will prevent the wood from absorbing the moisture from the putty, which could cause it to become brittle. Apply the putty in such a way that the glass does not touch the muntin bars. After the putty has been applied to "fix" the glass pane, allow the paint which is applied to the sash to cover the putty and extend slightly onto the glass to prevent moisture from reaching behind the putty and penetrating to the rail.

3.3 CUTTING GLASS

The cutting of old or reproduction glass should always be carried out on a cutting table with a thick baize cloth, to cushion the great irregularity in sections of these glasses. The baize cloth will allow pressure applied to the glass to be evenly distributed.

3.4 REPAIRING BROKEN GLASS

Repairing window glass in situ may be appropriate in some circumstances, such as when retention of an original pane is desirable or when it is important to arrest further damage to a partially damaged pane.

An adhesive used for repair should have a high viscosity to allow it to run into the crack; a refractive index of 1.52, which is similar to average glass; it should be removable and it should not yellow over time. Epoxy resins would appear to be most effective, although they have yellowing properties.

Two adhesives which have been specifically developed for glass repair are:

a. Opticon UV-5 is a single-component adhesive that is cured on the application of ultraviolet light. It is reversible in acetone, has a short shelf life and is expensive. It was designed for clear glass-to-glass bonding and has a refractive index of 1.53.

b. Maraglass No. 658 resin and No. 558 hardener are commercial two-part epoxy systems for bonding glass.

3.5 LEADED AND STAINED GLASS

3.5.1 Documentation

Before any work is conducted on a leaded, stained or painted window it should be well documented with photographs, preferably in colour.

3.5.2 In-Situ Maintenance and Repair

The interior and exterior of stained glass windows should be carefully washed clean with a 1-to-5 percent solution of ammonia and water using soft natural bristle brushes. They should then be rinsed thoroughly with clean water applied with a sponge, followed by polishing with soft cloths. This procedure should not be used where paint shows signs of deterioration.

Lead cames should be coated with linseed oil or microcrystalline wax to prevent oxidation. Any existing oxidation can be removed with fine emery cloth or by scraping with a knife. Putty should be checked and new putty should be rubbed in where missing. Where cracks appear in lights, place flanges over the top and putty them or else repair with epoxy. Missing or badly damaged glass should be replaced with duplicate pieces.

When a window is in a severely deteriorated condition it may need a more thorough and concentrated conservation program. This may require a careful dismantling of the window from its window opening and transportation to a studio.

4.0 WOOD DOORS

Wood doors, like windows, are subject to shrinkage and expansion. Doors and windows share many of the same problems and solutions.

4.1 PROTECTING EDGES

A common problem with doors is moisture absorption caused by the lack of paint on the bottom or the top where the end grain on the outer stiles is exposed. Lack of a protective coating in these areas can be the result of never having been painted or may occur from wear as the door rubs against the sill or

the head. This wear will accelerate the removal of a finish. Hence maintenance inspections of exterior doors should be made periodically. The treatment is the same as with windows. See Section 2.2.

4.2 PANELS

Wood doors with stiles, rails and panels should be constructed to allow the panels to "float" freely. In other words, the panels should be allowed to move, particularly across the grain and not be restrained by nails or screws or paint seals. It is important that bolection mouldings be fastened only to the rails and stiles, without having the fasteners penetrate the panels.

4.2.1 Repairing Cracked Panels

If a door has cracked panels, the panels should be freed from any restraints around their perimeter. The cracks should then be glued with an epoxy adhesive. Avoid the use of wood putty or other fillers; often acting as a wedge, they may force the crack to reopen.

Alternatively, a badly cracked panel can be replaced with a replica. This can be achieved by dismantling the door into its constituent parts and constructing a new panel which will be allowed to move or float within its frame.

4.2.2 Glazed Panels

Damaged glazed panels should be treated like windows. See 3.0 above.

4.3 STABILIZING JOINTS

The preferable means of stiffening joints is by dismantling the door and re-glueing or re-fastening its parts.

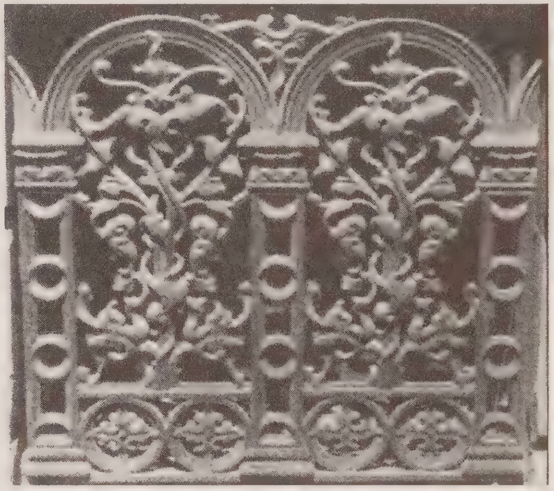
If the dismantling of a door is out of the question, then wood epoxies can be used to stiffen the joints. When wood sawdust is added to the epoxy, then the surface can also be built up.

4.4 CONSOLIDATION

Decayed areas of rails, stiles and panels can sometimes be consolidated rather than replaced, as a way of preserving original material. See 2.3 above.

4.5 REMOVING A DOOR

When removing a door from its hinges care should be taken to support the door. This will alleviate stress on the hinges. Screw heads and slots should have the paint removed. A screwdriver which matches the slot perfectly should be used so as not to destroy the slot. A sharp chisel should be used to cut the paint bond on all sides of the hinge, to avoid splintering the wood as the hinge is removed. If hinges have been altered many times and the wood beneath them is damaged to the point where it cannot support the door's weight, then a fresh piece of wood should be spliced into the frame or the stile below the hinge. Whenever hinges or other bits and pieces of door hardware are dismantled they should be carefully labelled and collected to prevent loss. See Section 4.6 "Hardware," for the stabilization of hardware.



Metal Components

5.0 METAL COMPONENTS

5.1 WINDOWS AND DOORS

Windows and doors are frequently fabricated of metals. Bronze and other copper alloys were especially popular early in this century, aluminum in recent decades.

5.1.1 Causes of Deterioration

The metal components are durable and require relatively little maintenance. The surfaces of most exposed metals oxidize naturally and form a stable finish; anodized finishes resist oxidation.

Damage may be caused by wear from frequent sliding or opening or from physical abuse. Corrosion from salt and acid rain can also cause deterioration. Soft finishes such as weatherstripping will require periodic replacement.

5.1.2 Means of Repair

Damaged windows and doors should be removed using the techniques described above with respect to wood components if appropriate. Metal surfaces should be cleaned and stabilized using techniques described elsewhere (see references in Section 4.3 "Stabilization of Iron and Steel Structures"). Damaged glazing should be stabilized or replaced as described in Sections 3.3 to 3.5.

5.2 HARDWARE

The stabilization of hardware is described in Section 4.6.

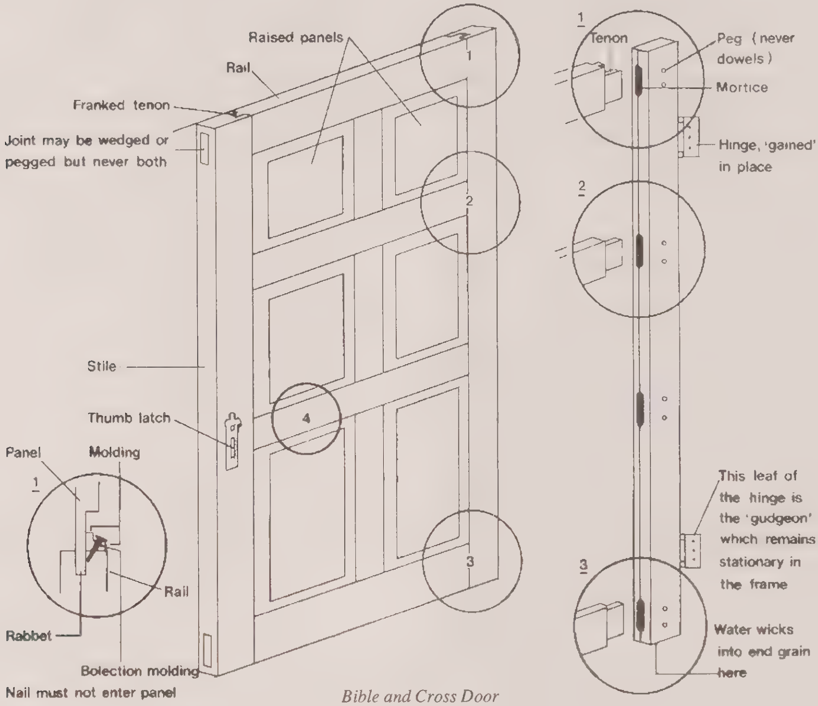
6.0 SUPPLIERS

6.1 ADHESIVES FOR GLASS REPAIR

a. K0A 300 and K0A 325 (U.V. Cured)
Kemxert Corporation
Cyber Center
1600 Pennsylvania Ave.,
York, PA. 17404
(717) 854-8907
Fax: (717) 854-9333

b. Sun-Set Glass Adhesive (U.V. Cured)
Lumen-Essence
1201 Rankin Drive,
Troy, MI 48083
(313) 583-0594

7.0 ILLUSTRATIONS



Bible and Cross Door

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

4.5
STABILIZATION
ROOFING MATERIALS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

A principal function of buildings is to provide protection from the weather. The roof is the primary element in the shedding of rain and snow. All roof material systems rely on one of two concepts for their external material. They consist of either a multitude of small overlapping units or continuous large sheets. In either type of system the areas where joints or overlaps occur are danger points. This is true not only for the joints within the roof system, but particularly for edge situations where the roofing is interrupted by a valley, ridge, eaves or any kind of protrusion, i.e., dormer, chimney, skylight or an adjoining wall. These interruptions comprise changes to a simple roof system designed to shed water directly as a unit. They cause water to slow down and change direction and cause snow to accumulate. The consequent concentration of moisture in these areas makes them likely candidates for failure.

Apart from shedding moisture, a roof must withstand considerable stress generated by the buffeting of wind. Roofs between 20° and 30° have wind pressure exerted uniformly upon them. Steeper roofs will have a higher negative pressure (suction) on the leeward side, while roofs with a slope less than 20° have a negative wind pressure on the windward side. Because of the significant wind pressures which must be withstood by the roof, the exterior roof cladding must be securely fixed to the subroof.

This manual focuses upon the stabilization of roofing and cladding materials. It also provides points to remember when inspecting roofs. After a careful inspection of a roof system has occurred, the question must be asked whether to stabilize it or replace it. If replaced, should the replacement be the same as the original or should it be designed to perform better than the existing materials? How much maintenance will the "stabilized" roof require? Outside factors may affect whether a roof is stabilized or replaced. This manual will begin to suggest the technical answers to many such questions.

2.0 WOOD SHINGLES

Wood shingles provide a durable surface at reasonable cost. When the individual units have been sawn they are called shingles; when they have been split they are usually called shakes.

2.1 CAUSES OF DETERIORATION

Wood shingles endure continuous abrasion and wear because of their exposure to water, wind and sunlight. Shingles may curl as well, which although a natural process, is usually the result of too great an exposed surface which can be prevented by proper design. Cracked shingles can be caused by multiple nails preventing slight movements from shrinkage or expansion related to changes in moisture content. Wide shingles (more than 20 cm wide) are particularly susceptible to cracks of this kind. Loose shingles may have been caused by careless walking on the roof or from fallen tree limbs. They may also have been a result of the shingles being placed too close together. Dry shingles should be placed approximately 60 mm apart. A wet shingle needs room for expansion or else it will buckle up and pull out its nails as well. In damp environments or in shady areas where a roof or a portion thereof never completely dries, moss may grow. This will rapidly accelerate deterioration because the mosses will slow water runoff, increase the moisture level in the shingles and encourage moisture backup and the growth of more moss and associated plants and fungi which will attack the wood fibres.

2.1.1 Inspection

After a roof has been carefully inspected, a decision should be taken as to whether to follow a minimum intervention effort of stabilizing the existing cladding or whether to completely replace the roof. The factors affecting this decision depend upon the particular problems associated with each roof and its condition. Factors such as the age of the shingles, the extent and location of damage, whether or not the damage is localized and specific and the historical significance of the roof cladding, should be considered.

2.2 REPLACEMENT OF INDIVIDUAL SHINGLES

If stabilization of the roof is the course of action to be followed, there are two methods for replacing deteriorated wood shingles.

A damaged shingle should be replaced by splitting it into smaller parts which are entirely free of nails. Cut the nail heads off with a hack saw slipped beneath the upper shingles. The replacement can be held secure by a 20 mm wide non-corrosive, metal tab nailed between two shingles to the sub-roof. The new shingle is inserted over the top of the tab and the metal is bent up to form a slot to hold the shingle.

The alternative method is to insert a new shingle in the cleared slot, letting it protrude by 60 mm below the adjacent shingles. Toe-nail two finish nails immediately below the upper course: using a hammer and a wooden block along the base of the replacement shingle, drive it up level with the other shingles. See Fig. 1.

2.3 TREATMENT FOR MOSS

Remove the moss and apply a mild fungicide such as zinc napthenate, which will kill any remaining organisms and prevent renewed growth for some time. Caution should be exercised when using any toxic chemical. Alternatively, the area from which the moss has been removed should be scraped and cleaned with a strong solution of water and household bleach. Repeat cleaning will be needed periodically.

Copper or zinc wires fastened to the roof at approximately one metre intervals down the slope will also inhibit moss growth, as will a copper or zinc flashing under the ridge and the dormer. Copper will react adversely with cedar; only zinc should be used with cedar shingles.

3.0 SLATE

3.1 CAUSES OF DETERIORATION

Slate is a very durable material and lasts considerably longer than most other roofing materials. Periodic inspections are still necessary, as slates can break because of either a sudden impact or freeze-thaw stress. Weathering and pollution can cause delamination. A slate can also fall off a roof if its nails have corroded. The failure of the slate nails due to rusting is generally always due to a poor original installation, where cheaper nails have been substituted for proper copper nails. If slates are falling off a roof, check the nails on slates that are still in place to determine their condition. If the roof must be reinstalled due to poor fixings (nails), undamaged slates can be reused.

The replacement of missing or deteriorated slates on an otherwise sound slate roof is far less expensive than complete replacement and provides better value over the life of the roof than covering it with a less permanent material.

3.2 REPLACEMENT OF INDIVIDUAL SLATES

There are two techniques for holding a new replacement slate in a roof. The first involves nailing the replacement slate through the vertical joint of the slates in the overlying course and covering the nail head with a strip of copper, bent in a concave or convex profile. The second technique employs a long copper holding tab which is inserted up under two or more slates of the overlying course and is nailed to the roof boarding through the joint of the underlying course. The replacement slate is slipped into position and the copper tab bent up to secure it in place. See Fig. 2. In all cases, the nails should not be driven tight against the slates, as this may lead to cracking. The purpose of the slate nails is to provide a fixed surface on which the slate will "hang."

4.0 METAL

Metals are used as roofing in sheet form and as shingles. Standing seams are the most common for sheet metal; these usually occur perpendicular to the eaves, but angled seams are also found. Metals used include lead, copper, zinc, tin plate, terneplate and galvanized iron.

4.1 CAUSES OF DETERIORATION

Iron roofs rust unless painted, plated or galvanized. The coating will wear in time and so an iron-based roof must be kept painted. All metal roofs are subject to deterioration by chemical action. This may be caused by acid rain, galvanic action from different adjacent metals, acids from moss or cedar shingles or alkalies from lime mortars. Metal fatigue, accelerated by thermal expansion and contraction, will also cause deterioration.

4.2 METHODS OF REPAIR

Before painting rusted areas, scrape with a wire brush and apply an iron oxide metal primer.

Individual damaged shingles are extremely difficult to replace because of the way in which they interlock. The most permanent method of repair for a roof of either shingle or sheet metal is to solder a patch. A temporary patch with flashing cement and sheet metal can also be installed. The metal should be cleaned with steel wool and a household cleaner to remove surface grease. The sheet metal patch should overlap the hole by at least 70 mm on all sides. Coat the back with flashing cement and press the patch firmly into place. Follow by painting the patch with primer and a finish coat to match the existing roof.

Soldered seams in sheet metal roofing can be resoldered if they have opened up. However, they may open again, unless expansion joints are installed, since the cause of their opening was likely expansion and contraction in the metal sheets.

5.0 TILES

Clay tiles have long been an effective roofing material. Flat tiles attached with nail or peg fasteners behave much like slate. Curved pantiles (also called Spanish tiles) have enjoyed moderate popularity in Canada since the revival of the Spanish Colonial and Mission Styles in the 1920s.

5.1 CAUSES OF DETERIORATION

Tiles will crack on impact and so breakage occurs from fallen branches, other projectiles and careless walking on the roof. Cracking and breakage also appears to result from severe freezing and the freeze-thaw cycle of the Canadian climate. This kind of damage usually occurs in the form of corners breaking off.

5.2 REPLACEMENT OF INDIVIDUAL TILES

Individual tiles can be replaced by an experienced roofer using the method of replacing slates and holding them in place with a metal tab. (See 3.2 above). Remaining pieces of broken tiles should be removed by breaking the tile into small pieces with careful hammer blows. The nail which was holding the broken tile can be cut with a hacksaw blade inserted beneath the next higher tile. A copper tab is fastened to the nailer strip. A new tile is inserted and the tab bent to hold the tile in position. See Fig. 3.

Replacement tiles may be available through a local salvage firm. Alternatively, three firms in the USA continue to manufacture clay tiles:

Ludowici-Celadon Inc.
P.O. Box 69
New Lexington, OH 43764
(614) 342-1995
Fax: (614) 342-5175

Gladding, McBean & Co.
P.O. Box 97
Lincoln, CA 95648
(916) 645-3341
Fax: (916) 645-1723

Midland Engineering Co.
P.O. Box 1019
South Bend, IN 46624
(219) 272-0200
Fax: (219) 272-7400

6.0 ASPHALT (ROLL OR BUILT-UP ROOFING)

Asphalt roofing, introduced in the 1890s, has become the most common roofing material because of its relatively low cost. Although it is relatively fire-resistant, it is also the least durable and so requires frequent maintenance and replacement.

Individual damaged shingles can be replaced by lifting the shingles above them and inserting a new shingle, nailing with roofing nails and applying an asphalt mastic. Care must be taken to do the work when the shingles are pliable. Cold weather makes the shingles brittle; very hot weather makes them soft and liable to mechanical damage.

Small leaks can sometimes be patched successfully with asphalt mastic. Large leaks will usually require the replacement of a section of roof.

Most of the leaks in flat roofs occur where the roofing is interrupted by a parapet, wall, chimney, skylight or vent pipe. Cracks at these locations can be repaired as indicated in Fig. 6. To repair a small patch of a flat roof, follow the following procedure: neatly score and cut out around the damaged area, being careful not to damage underlying layers of felt. On a built-up roof, scrape gravel away. Pick a day when the gravel is not sticking to the roofing. Trace the outline of the flawed piece onto a new sheet, generously spread roofing cement on the cut out area and under exposed edges and press the replacement patch into the cut out. Nail down the perimeter of the patch and cover with roofing cement. Cover the first patch with a second which overlaps by 50 mm on all sides; nail down the perimeter and cover with roofing cement. See Figs. 4 and 5. For a longer service life, sprinkle the roofing cement with mineral granules, fine gravel or sand while the cement is still plastic, in order to reflect the sun's rays and help prevent cracking.

7.0 FLASHING

All flashings are potential danger points. Installed to waterproof the junctions between slopes of roofs, roofs and walls and around chimneys, skylights and vent pipes, flashings will frequently fail before the roofing material itself.

The same principle of overlapping units used for most roofing systems is the basis of flashings.

When a flashing fails, it cannot usually be repaired, but must be replaced. It is good practice to use a durable material (copper is best; galvanized steel is good) and to allow sufficient overlap at both surfaces. Where the roof meets a wall or a parapet, the flashing should continue at least 10 mm beneath the wall siding and at least 10 mm over the roofing. See Figs. 7 and 8.

Copper or zinc flashing will act as a moss retardant on wood roofs, but copper flashing should not be used on cedar roofs.

8.0 EAVESTROUGHING

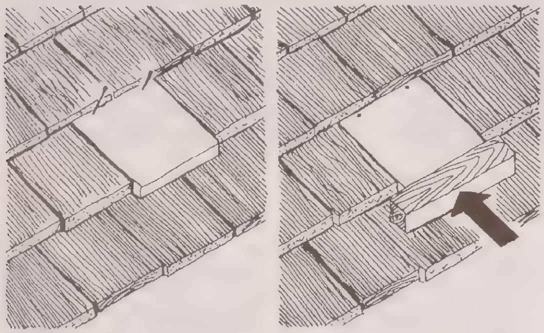
8.1 INSPECTION

Regular maintenance and repair is an essential part of maintaining a functional eavestrough. If eavestroughs are allowed to become clogged, they can frequently cause moisture to back up and enter the structure at the eaves. Downspouts should be inspected during a rainfall to determine if water is flowing unimpeded or if they may be leaking, thereby shedding water onto a wall and causing high moisture levels.

8.2 STABILIZATION AND REPLACEMENT

Minor damage can be repaired, using a method which is appropriate for the eavestrough material (usually wood, metal or plastic). Severe damage will usually indicate that the eavestrough should be replaced.

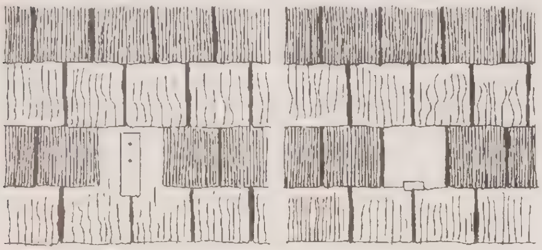
9.0 ILLUSTRATIONS



THE HIDDEN NAIL METHOD

1. After removing damaged shingle, slip in replacement. Let it protrude ¼ in. below other shingles in the course. Toe-nail two finish nails immediately below upper course.

2. With hammer and wooden block, strike the end of the new shingle, driving it up level with the other shingles. This bends the nails and puts heads below upper shingles.



THE COPPER TAB METHOD

1. Nail a strip of 1-in. copper (20 oz.) in area of missing shingle. Use copper roofing nails.

2. Insert new shingle and bend tab up. Trim off any excess so sliding ice and snow won't loosen tab.

Fig. 1 Replacing Wooden Shingles
The Old House Journal, *April 1983, p. 67.*

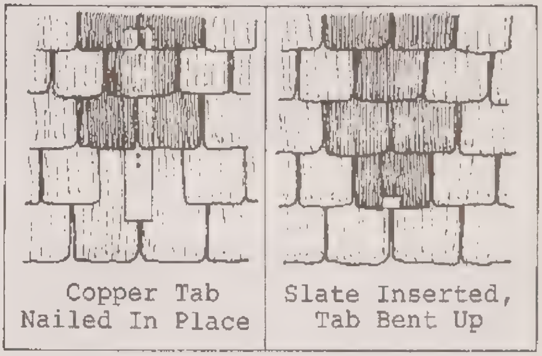
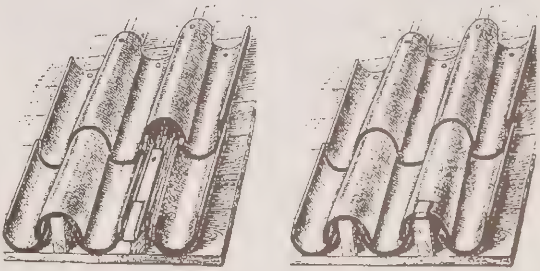


Fig. 2 Securing Slate with a Copper Tab
The Old House Journal, *May 1980, p. 55.*



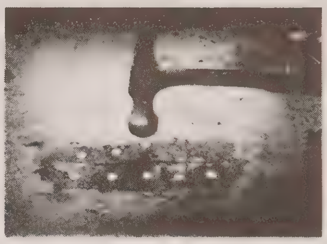
1. After removing broken tile, fasten copper tab to nailer strip. Use a copper nail.

2. Slip new tile in place and bend copper tab up to hold the tile in position.

Fig. 3 Replacing a Broken Barrel Tile
The Old House Journal, *April 1983, p. 68*

A

B



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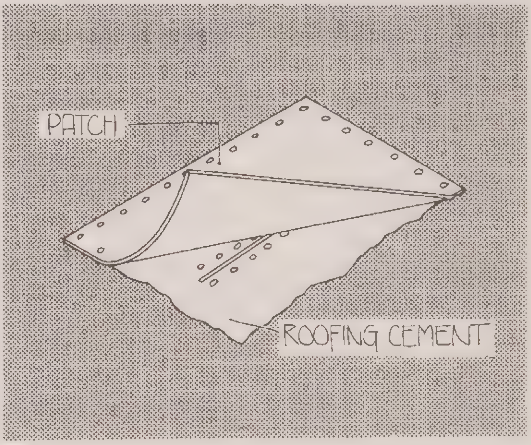


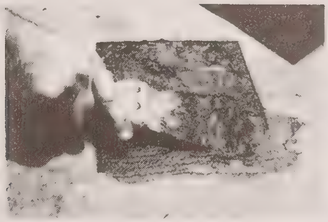
E

Fig. 4 Repairing a Flat-roof Blister

(A) Cut the blister with a utility knife; don't cut too deeply.
(B) After allowing moisture within the blister to evaporate, apply roofing cement under both sides of the cut.
(C) Nail down both sides of the cut with roofing nails.
(D) Cover the entire area with roofing cement.
(E) Nail a repair patch over the entire area and cover it with cement.

M. Litchfield, Renovation: A Complete Guide, *p. 103.*

A



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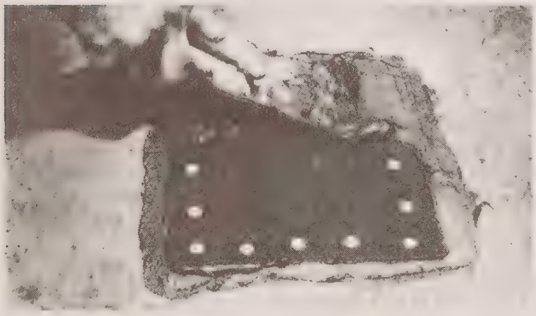

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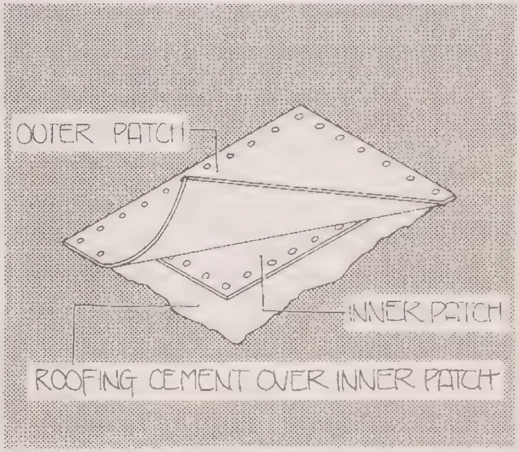

E

Fig. 5 Patching a Flat-roof Flaw

(A) After scoring around the flawed section, gently pry it up.
(B) Spread roofing cement over the exposed area.
(C) Trace the flawed piece of felt paper onto replacement stock, cut it out and press the new piece into place.
(D) After nailing around the perimeter of the replacement patch, cover it with roofing cement.
(E) Cover the first patch with a second, larger one; nail and cement it into place.

M. Litchfield, Renovation: A Complete Guide, *p. 104.*

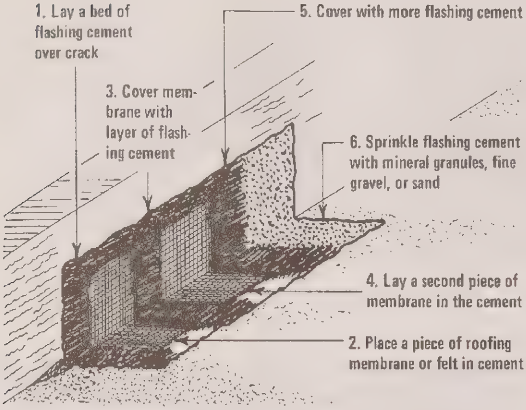

Fig. 6 Repairing a Crack in Asphalt Flashing
The Old House Journal, *April 1983, p. 65.*

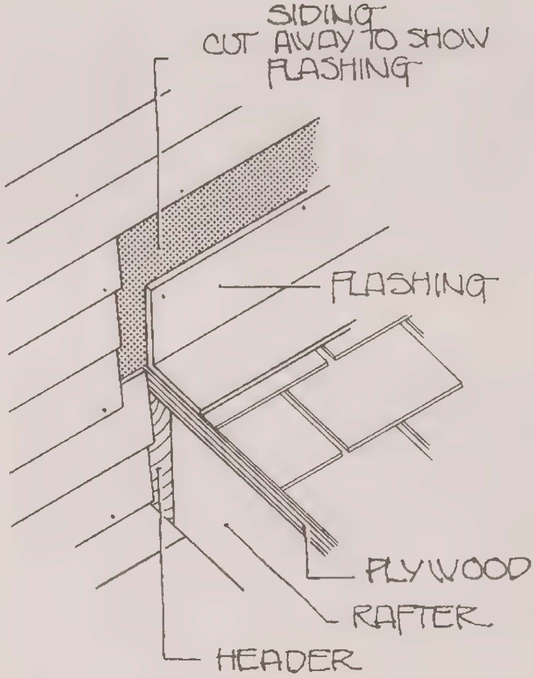

Fig. 8 Flashing Where a Shed Roof Meets a Wall
M. Litchfield, Renovation: A Complete Guide, *p. 112.*

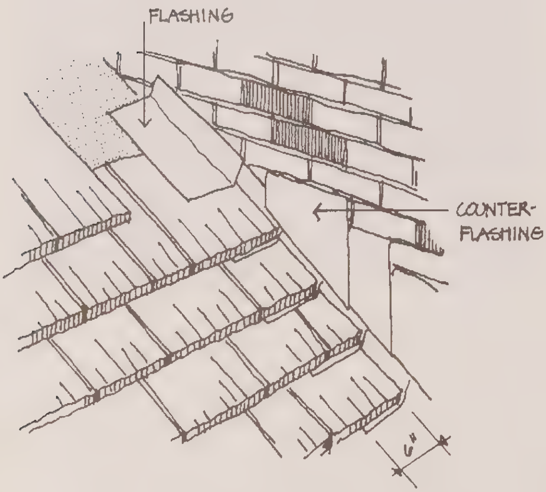

Fig. 7 Flashing and Counter-flashing a Roof
The Old House Journal, *August 1977, p. 94.*

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

4.6
STABILIZATION
BUILDING COMPONENTS: HARDWARE

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

The purpose of this document is to guide technical and professional staff in techniques which may be used to stabilize hardware. The following techniques range from routine maintenance to the repair or replacement of hardware. The stabilization of an artifact implies minimum intervention. Therefore the objective in each case is to retain as much of the original hardware as is feasible.

1.1 TYPES OF HARDWARE

Hardware is the term used to describe many kinds of items used in buildings, from nails to clothes hooks. Most are metal objects.

The following classification system may be used to categorize the majority of hardware found in historic sites:

1.1.1 Staple Hardware (or Rough Hardware)

The term is used to describe hardware that is useful rather than ornamental in appearance.

a. Nails
- Cut nails
- Wire nails

b. Screws
- Wood screws
- Metal screws

c. Bolts
- Standard bolts (used with nuts and washers)
- Expansion bolts
- Toggle bolts

d. Chains

e. Pulleys

f. Hardware for double-hung windows
- Sash weights and balances
- Sash pulley
- Sash cords or chains

1.1.2 Finishing Hardware (or Builder's Hardware)

Also intended to serve a function, finishing hardware has also been designed with its ornamental appearance as an objective.

a. Hinges
- Strap hinges
- T-hinges
- Butt hinges
- Hinge plates

b. Locks
- Rim locks
- Mortise locks
- Cylinder locks
- Escutcheons

c. Door hardware
- Knobs
- Pulls
- Plates
- Thresholds
- Fasteners
- Bolts
- Closers
- Knockers

d. Window hardware
- Sash fasteners
- Sash lifts
- Sash sockets and pole hooks
- Casement adjusters
- Bolts
- Sash pivots
- Transom lifts

e. Shutter hardware
- Shutter fasteners
- Turnbuckles

f. Cabinet trim
- Latches
- pulls

g. Miscellaneous hardware

(Note: This list is adapted from I.C.S. *Builders' Hardware*, Scranton International Textbook Co., 1939.)

1.2 MATERIALS AND FINISHES

Materials used for hardware have been wrought iron, cast iron, steel, brass and bronze. Other metals have been introduced in recent years, but need not be considered here. A variety of finishes has been applied, usually by electroplating or acid treatment on natural metals. The finishes usually lack the durability of the actual metals.

Other materials are sometimes used for hardware, such as glass, ceramics, wood and recently plastics, but this manual focuses on metal hardware.

1.3 PROBLEMS IN STABILIZING HARDWARE

Unlike other metal artifacts, hardware is often treated in place because of difficulty in removal. Hardware remains in the same environment after treatment as before, which gives rise to the recurrence of the original causes of deterioration. Therefore it is necessary to remedy those causes. When costs and time make the stabilization of hardware impracticable, document the location of the hardware, carefully remove it, store it and treat it as an artifact.

2.0 CAUSES OF METAL DETERIORATION AND FAILURE

2.1 CORROSION

Corrosion is nature's way of turning refined metals back to their natural state. Corrosion can take the form of uniform attack, localized pitting or selective corrosion in alloys. Some metals show stress corrosion cracking where they have been bent and then exposed to a polluted atmosphere. Abrasion from friction, handling or rubbing against other building components can erode the protective film in metals such as aluminum and lead to further corrosion. For abrasion, see below.

a. Galvanic corrosion takes place when two dissimilar metals are together in the presence of an electrolyte such as acid rain or salt water. The less noble metal will corrode first. (e.g. in the case of copper held in place with iron fixings, the iron will corrode first.) The rate of corrosion depends on the ratio of noble metal to base metal.

b. Oxygen concentration will speed corrosion. Oxygen can become trapped between two metals or between a metal and a foreign substance (e.g. a gutter and tree leaves).

c. Atmospheric corrosion is the greatest problem for architectural metals. The film which forms naturally on metals contains gases. Moisture in the air combines with the gases to produce acids which corrode the metals in hardware.

d. Salts (e.g. fluorides and chlorides) produce corrosion, particularly in areas where road salt is used to melt ice and snow.

e. Bird droppings are another cause of corrosion for architectural metals.

2.2 ABRASION

Abrasion in the form of dirt, dust, sand, grit, sleet, hail and human handling wears down hardware such as door plates and thresholds.

2.3 FATIGUE

Fatigue, produced by thermal expansion and contraction or by conditions of continued stress will cause metals to fail.

2.4 CREEP

Soft metals will flow or creep under high temperatures.

2.5 CONNECTION FAILURE

Connection failure may occur when bolts, rivets, pins and welding suffer from overloading, fatigue or corrosion.

3.0 STABILIZATION TECHNIQUES

3.1 MAINTENANCE

Regularly inspect hardware to detect the first signs of failure. Adjust screws in locks and hinges so that the hardware is not loose – and therefore not easily damaged – during normal use. Lubri-

cate still locks, pulleys and hinges. Use a liquid stripper to remove paint build-up on hinges which can cause doors to bind and hinges to snap. (See also Vol. V.2.2 "Maintenance Procedures.")

3.2 PROPER INSTALLATION

The proper installation of new or replacement hardware will reduce potential maintenance problems. Select new metals that are compatible with existing ones. Avoid physical or electrolytic contact between dissimilar metals or any condition that may cause galvanic corrosion. Remove trapped water and prevent its accumulation. Minimize stress and fatigue from extremes of heat and cold by providing for thermal expansion and contraction. Allow for over-sizing and allow extra thickness in potentially high-abrasion areas such as thresholds.

3.3 ENVIRONMENTAL CONTROLS

Where possible, dehumidify a moist environment. Prevent salts from settling on hardware.

3.4 APPLIED COATINGS

Before applying protective coatings it is necessary to clean the metal of any existing corrosion. First thoroughly examine the hardware and x-ray it if it is necessary to determine its condition. In consultation with conservators, determine the level of "clean" which is desired. Provide protection for workers and surrounding materials.

3.4.1 Cleaning

Three categories of cleaning are chemical, thermal and mechanical:

a. Chemical cleaning can be accomplished with liquid rust removers. Beware of commercial preparations which may contain strong chlorides and thus may cause a new set of conservation problems. Immersion minimizes oxidation. Cleaning must be followed by the application of a dewatering agent and a protective covering.
b. Thermal cleaning is achieved by heating hardware with an oxyacetylene burner and scraping off the corrosion. This technique should not be used in situ, as there is a risk of the burner charring or igniting adjacent wood or other flammable materials.
c. Mechanical cleaning allows for the softening of corrosion by the use of a penetrating oil followed by rubbing in one direction with a fine emery cloth. Do not use steel wool on copper alloy hardware. Bronze wool, available from sailing supply stores, will prevent galvanic corrosion. This technique is abrasive and prolonged polishing can lead to loss of detail and the erosion of thin electroplating.

Other mechanical cleaning techniques include scraping, wire brushing, glass bead peening and wet/dry grit blasting. Pits produced by dolomite grit provide a key for lacquer finishes.

3.4.2 Finish Coatings

Finish coatings for metal hardware include lacquers, varnishes and waxes; enamels, bituminous coatings, inert fillers and ceramic-type pigments are occasionally used as well. Coatings can be applied by wiping, electro-deposition, spraying and dipping. Lacquers last longer, but waxes are easier to renew when the protection loses its effect.

3.5 MECHANICAL REPAIRS

Hardware can be patched by mending, covering or filling voids with metal powders consolidated with cold-setting synthetic resins. Watch for cathodic reaction between dissimilar metals.

Splicing is a structural repair which allows the elements to act as a unit. Reinforcement supplements old hardware with new material. It does not replace any metal in the hardware.

3.6 DUPLICATION AND REPLACEMENT

Components that cannot be repaired should be replaced, whether by duplication or by purchasing off-the-shelf pieces. Replacement hardware should be matched for composition, size and the configuration of details. The "Design Criteria" (Section 2) will determine whether the replacements will be readily apparent, or whether they will appear to be original.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

4.7
STABILIZATION
PERIOD MACHINERY

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
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PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: A. WILDSMITH

CONTENTS

1.0 INTRODUCTION

The purpose of this article is to provide general guidance and instructions for the stabilization of historic machinery. It is intended for use by technical and professional personnel who are directly engaged in the stabilization of historic machinery, by other professionals who have funding or scheduling responsibilities for historic site or structure development and by members of interdisciplinary project teams.

1.1 DEFINITION

In this document "stabilization" refers to both short-term protective measures and long-term preservation.

2.0 PREPARING FOR STABILIZATION

2.1 GENERAL REMARKS

Temporary stabilization involves the application of techniques designed to provide short-term protective measures while awaiting long-term preservation or adaption. These techniques include interim cleaning and coating of badly corroded machinery; structural stabilization; interim environmental control programs, including temporary waterproof shelters; and interim safety and security measures. The primary emphasis is on protection, i.e. maintenance of historic machinery and the structure that shelters them in an "as found" state.

Stabilization of Period Machinery

Long-term stabilization involves the application of techniques designed to preserve and consolidate existing historic machinery for an extended period, as part of site development. Techniques include the use of chemical preservatives, cleaning agents and coatings; and limited replacement of missing and deteriorated components. Dismantling and reassembly can also be included to the extent that it is applied to only a portion of the work and the historic material is treated and reused in its original context.

2.2 TERMS OF REFERENCE

The technical professional responsible for carrying out the stabilization work should review the terms of reference with the project manager. The terms define and describe the nature of the task to be done, the limitations and constraints and the format for documenting and reporting the work carried out. The professionals responsible for the stabilization must be aware of the historic value of the machinery and be familiar with its working principles and construction.

2.3 BACKGROUND DOCUMENTATION AND INFORMATION

The technical person responsible for the stabilization work should gather existing documentation relevant to the machinery. It should include all historical documents, maintenance records and condition reports. Valuable information is also obtained from manufacturers' operating and maintenance manuals, including plans and parts lists.

2.4 EQUIPMENT AND SPECIAL TOOLS

The technical officer may find the following tools useful from time to time during the stabilization of historic machinery:

a. Camera:
A camera allows for documenting the "as is" appearance of such things as rot, corrosion and missing parts. Photographs should be 20 x 25 cm from a combination of black and white and colour films. Make the image as clear as possible. Write the machine nomenclature and primary reason for taking the photo on the back. A technical pen does not require any pressure and helps to avoid embossing the emulsion face of the photo.

b. Graph Paper and Pencil:
If the machine has not been adequately recorded with measured drawings, prepare sketch plans and note main dimensions. These illustrations (measured drawings or cursory sketches) should be clearly produced and should be referred to in notes. Use also a photo-key document.

c. Special Tools:
Obtain a range of spanners, both open jaws and ring, to fit every nut and union on the machine (including "C" spanners for rack nuts), a set of Allen set screw wrenches, together with a selection of box spanners to extract hard-to-get-at nuts; a light-weight hand hammer (less than one kg) and a heavy hammer (over three kg), plus a variety of chisels, bars and pin punches. A stout bench with a strong, secure 15 cm vice and a selection of flat, round and square files will be necessary for most stabilization work on historic machinery.

d. Lifting Appliances:
Two hydraulic jacks of appropriate capacity are an adequate supply for removing frozen shafts, bearing sleeves, etc. A suitable chain block is also convenient for lifting heavy cylinder covers, small machines and other heavy components.

2.5 SITE FINDINGS

The site may have only one machine on it such as a steam crane, a printing press or a piece of farm machinery. Or the site may be a complex assemblage of interrelated machinery in a shelter such as a fish processing plant; or steam and internal combustion engines in combination with lathes and other industrial machinery. Some machines may be intact, while others are represented by ruins or remains of a large piece of industrial equipment. When stabilization is carried out, each and every piece of equipment should be dealt with individually and identified in its position in the shelter. Single items of equipment exposed to the atmosphere should be identified on the site plan.

Become familiar with the assemblage of machinery. Make note of any of the units which may require the assistance of a technical specialist (such as a steam and internal combustion engineer, painting millwright, farm equipment manufacturer, welding/brazing personnel). Contact the regional conservation unit for advice and assistance.

2.6 SECURITY

One of the immediate requirements in stabilization of historic machinery is to ensure a proper environment for the machine and its components once they have been located. Temperature and humidity should be controlled as much as possible, harmful substances eliminated and the machinery guarded against vandalism and fire.

2.7 SAFETY

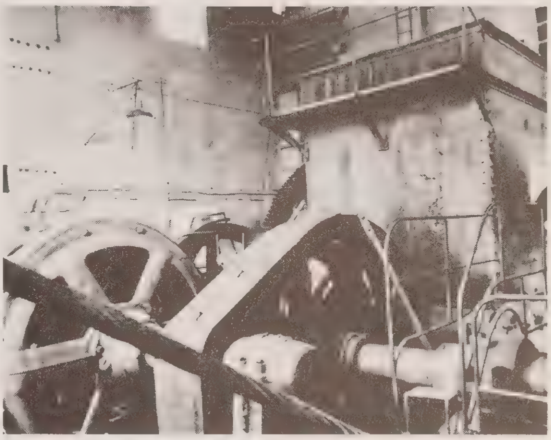
For safety considerations in connection with the work of stabilizing machinery see Vol. III.7.1 "Investigation and Analysis of Marine and Industrial Sites: Period Machinery," para. 2.4.

3.0 STABILIZATION

One objective of stabilization is the protection of as much historic fabric as possible. Any changes to historic material must be well documented. The other objective is to ensure structural security of the protecting shelter, of the support brackets or other framework for mounted machinery, and of the individual elements of interdependent or composite machines such as furnace systems. Stabilization treatments do not last indefinitely and improved conservation methods and techniques may become available in the future. As many of today's treatments are reversible, the option to re-treat is always open and the continued stabilization of the material is assured.

3.1 PRELIMINARY EXAMINATION OF MACHINERY

When objects are treated, the basic attitude and approach should be cautionary, as the past history of a machine will impart features of significance pertaining to age and provenance. To this end, a preliminary examination of the machine needs to be made to determine a course of action that will preserve the integrity of the machine and maintain any significant attributes or any features relating to its manufacture or microstructure.



Dredge No. 4 – Dawson, YT

3.2 TEMPORARY STABILIZATION (IRON AND STEEL)

Machines may be badly corroded. Loose dirt should be removed with soft brushes or similar instruments. The metal parts should be washed with a petroleum-based machine cleaning liquid. Care must be taken as the removal of thick layers of corrosion products may be destructive to the component itself.

If in doubt concerning what temporary stabilization technique to execute on badly corroded machines, contact a conservator and together study each unit, note the extent of the oxidation that has occurred and then choose the best technique for stabilization of the unit.

In an emergency, the rust may be soaked with melted wax as a temporary conservation measure.

Following the cleaning operation all the ferrous metal surfaces which will not be painted should be given a light coating of oil.

If touch-up painting is required as a temporary stabilization measure, a non-corrosive and easily removable paint should be used. Ensure that no original paint is removed and that the original paint is distinguishable from the temporary.

3.3 TEMPORARY STABILIZATION (BRASS, BRONZE AND COPPER)

Most non-ferrous metal corrosion can be removed easily with a mild chemical and abrasive mixture applied by hand. Such compounds as rotten-stone and oil or whiting and ammonia may be employed. Care must be taken when cleaning soft non-ferrous metals as the danger of too harsh an abrasive could cause damage. Be careful not to blur the machine's identification plate; it contains important information such as model, serial and specification numbers. Lacquer is the most satisfactory coating to prevent brass or copper from corroding. Make sure that surfaces are absolutely clean and that no trace of oil or cleaning compound remains when applying lacquer to ensure adequate adhesion. The engineering design for temporary supports should be prepared by a professional engineer with some knowledge of the principles of historic machinery design. The following points should be considered in the design:

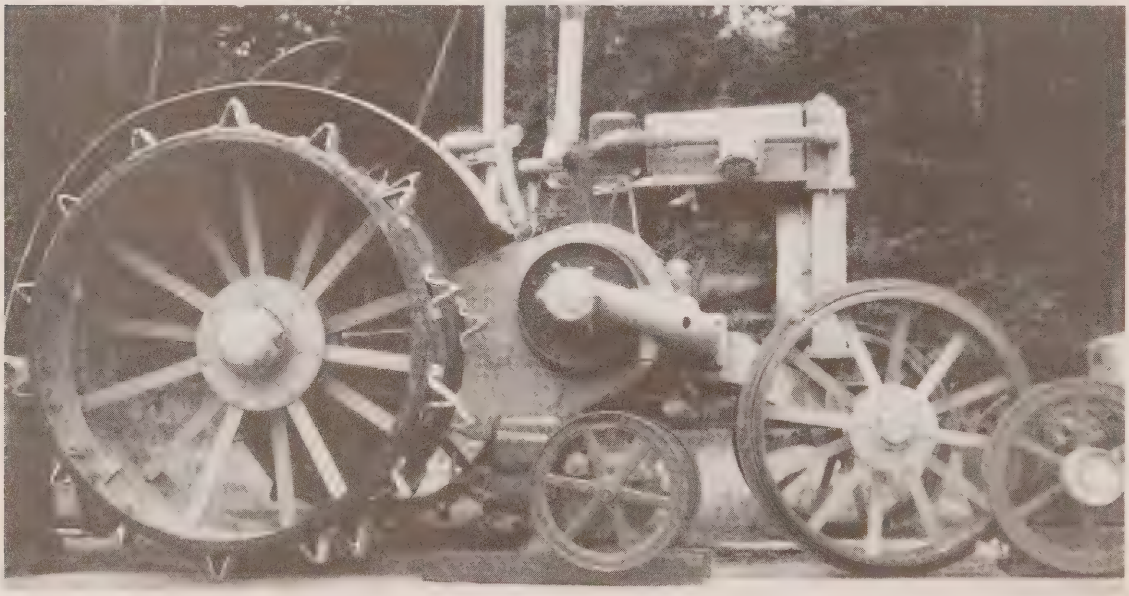
a. minimal damage to the historic machine;
b. provision for working on long-term stabilization;
c. ease of dismantling; and
d. visible differentation.

3.4 LONG-TERM STABILIZATION

The execution of long-term stabilization (in addition to items described in the previous paragraphs) should include the following:

a. stripping of the machinery as completely as possible in a methodical order;
b. tagging of the various bits and pieces with nomenclature clearly printed in waterproof ink; and
c. cleaning of each component to remove dirt, oil, grease and other coating (aside from the original finish).

When the cleaning has produced an appropriate surface appearance, which has been allowed to dry, the components should be coated with carefully selected oils or greases and set aside. When the technical person is satisfied that all components are prepared the machine should be reassembled making sure that the various bits and pieces are correctly replaced in sequence. It should be noted that the lack of witness marks and of method, causes much time and energy to be wasted in searching for lost components and replacements. Parts should only be repaired or new parts procured if they are required to ensure the structural



Farm Tractor, near New Denver, BC
Photo courtesy of A. Barbour

stability of the machine. After assembly most exposed metal surfaces (except for copper, brass, stainless steel, aluminum and steel shafting) should be painted. Apply coatings as directed by a conservation laboratory. Remove all paint from the special exposed units/surfaces. Since long-term protection and exterior appearance are the primary requirements for historic machinery, there is frequently no need for components to rotate. At the earliest possible moment document the machine with both photographs and measured drawings. Make records before dismantling and again when reassembled. Save samples of all discarded material. Their analysis could be important for subsequently documenting the history of the machine.

Boilers: refer to Section .4.8 "Stabilization: Period Vessels."

4.0 MAINTENANCE

In addition to an up-to-date inventory and other technical documentation for each stabilized unit, effective separate maintenance guidelines are required for each machine. In the preparation of such guidelines consider the following factors: frequency and level of inspection, time and tools required to conduct an adequate survey and a logical sequence or circuit of inspections for complex sites.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

4.8
STABILIZATION
PERIOD VESSELS

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ORIGINAL DRAFT: A. WILDSMITH

CONTENTS

1.0 INTRODUCTION

The purpose of this article is to provide guidance and instructions to technical and professional personnel who are charged with the stabilization of historic marine vessels.

1.1 DEFINITION

A historic vessel – a general term for a floating structure that carried passengers or cargo, noted in history or associated with a person, place or event of historical significance or representing a specific type.

2.0 PREPARING FOR STABILIZATION

2.1 TERMS OF REFERENCE

The person charged with the stabilization task should review the terms of reference with the project manager. The terms of reference define and describe the purpose of the task and should determine whether the stabilization will be carried out by a consultant, in-house personnel or other government agency. Regardless, the technical person responsible for the stabilization should be knowledgeable about the historic values associated with the vessel and be familiar with the period of construction. Other information to be reviewed includes basic project objectives and constraints.

Stabilization of Period Vessels: S.S. Klondike

2.2 BACKGROUND DOCUMENTATION AND INFORMATION

Before proceeding with the work, the person charged should gather existing relevant documentation. This information should be assembled in collaboration with the project team. It should include all historic and contemporary records which will contribute to an understanding of the vessel's evolution, recent investigation, temporary protective measures, maintenance and present status.

2.3 VESSEL FINDINGS

The responsible person should examine the vessel and make note of areas of neglect, missing elements and internal and external deterioration, before deciding details of procedures and schedules. Note should be taken of any items which would require the assistance of industrial chemists for gas analysis of spaces, and divers for underwater external inspection. It is also important to identify such items as the need for cleaning, or the removal of stores, oil and coal; the location of services, dry docks, staging and tugs and the availability of work crew(s).

2.4 SAFETY AND SECURITY

For basic information in connection with safety and security, see Vol. III.7.2 "Period Vessels" Paragraph 4.5.

2.5 TESTING

Where sections of the vessel have been obviously deformed or misaligned or where the deflection as a whole is subject to serious sagging strains, then the area of stress should be tested. Engage a reputable hull-testing consultant to check for concealed cracks or other damage. If suspected, arrange for a stress test.

3.0 STABILIZATION OF VESSEL

The primary objective of stabilization is to protect historic fabric, by arresting ongoing deterioration. Every effort should be made to preserve as much as possible of the original elements and components. A second objective is to impart structural strength where breakdown of a unit is threatened.

Following the examination of the general framing systems, the type of bulkheads, the type of construction and the layout, ensure that freeing all compartments of gas has been completed. Establish the types of accessible damage and deterioration and possible remedies and then prepare a sequence of events and a schedule. The order of stabilization may vary depending on the type of vessel, especially the type of hull (steel or wood) and whether the vessel is afloat or if it is hauled out and resting on cribs or other supporting framework.

4.0 AFLOAT

4.1 STEEL HULLED VESSEL

Dry dock or haul-out the vessel for stabilization work. Aside from the original hull coatings above the waterline, which may be of historic significance, remove all loose paint, rust and scale by grinding, wire-brushing, scraping or using chemical paint removers. The underwater portion of the hull should be cleaned by light sand-blasting; the zinc anode/cathodic protection plates replaced, propeller shaft sealed and all sea intakes fitted with blank flanges inboard of the valves. When good sound cleaning has been accomplished, loose rivets and seams of lap plates recaulked and air pressure and water spray tests are satisfactory, paint both the underwater and above water bare hull plating after consultation with the conservator and a paint representative of an approved manufacturer.

In cleaning the steel deck and the interior hull of the ship, the person charged with the stabilization should be sure that all existing deteriorated painted surfaces are thoroughly cleaned and coated as necessary. Refloat the vessel.

4.1.1 Internal and Weather Decks

Where serious corrosion is localized in frames, beams, brackets and knees to the point of being undersized and risking collapse, the loss of strength can be compensated for by sistering new sections or by overplating the area of deterioration and fastening them to the structure in areas where the structure is sound. All contact surfaces between the new and existing members should be clean and dry and the whole coated after the stabilization. Where only fastenings are deficient or deteriorated they may be replaced after reaming the holes. Where connections are just loose, if bolted, the bolts may be retorqued to the allowable stresses using appropriate torque wrenches. Corrosion between contact surfaces of steel deck beams and deck plates is a relatively common problem. If the loss of

material is not so severe that strengthening is required, further problems can be prevented by making sure that all rust and scale are removed and then seal-welded to prevent the intrusion of moisture. Components should only be repaired or renewed if they are required to ensure the structural stability of the vessel. With reference to coal bunkers, oil and water tanks, coal ventilators, davits, anchor chain stopper seats, water-ways (gutters), deck fastenings or steering gear, localized corrosion of the ships items is very common. Remedial treatment (caulking, sealing followed by protective coating) of these units to protect the steel from further deterioration should be done.

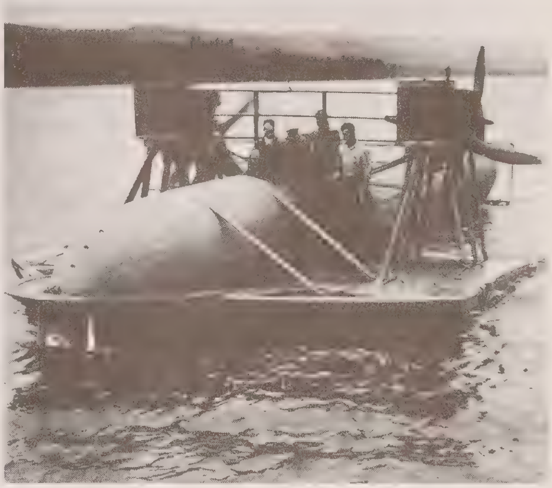
4.2 WOODEN HULLED VESSEL: EXTERNAL

As with a steel hulled ship, wooden structures floating in water are in a hostile environment and attention to the skin of the hull is of paramount importance. Dry dock or haul out the vessel. Remove all marine growth from the entire underwater portion of the hull by water washing. With the exception of the original hull coating above the waterline, remove all loose paint by wire-brushing and scraping. The underwater portion of the hull should also be cleaned, but care must be taken as the removal of thick layers of marine growth and paint may be destructive to the hull. The zinc anode/cathodic protection plates should be renewed; the tail shaft sealed and all sea inlets fitted with blank flanges inboard of the valves. When a satisfactory surface of the hull is obtained and water spray tests are satisfactory, paint the entire bare surface, after consultation with the conservator and an approved paint manufacturer's representative. The vessel may then be refloated.

4.2.1 Internal and Weather Decks

In cleaning the wooden weather decks and the interior hull of the vessel the person charged with the stabilization should be sure that the existing deteriorated painted surfaces are thoroughly cleaned.

Where serious rot is scattered throughout the vessel and it would be difficult to replace the rotted wood, defective areas should be treated with fungicide and subsequently strengthened with fiberglass, epoxy resins or new wood spliced in. Care should be taken that the structural material is fashioned to conform with the original profile of the timber. For technical considerations with regard to chemical preservative treatments of wood and strengthening of timber see Section 4.2.



Wooden Hulled Vessel: HD4 Hydrofoil
Alexander Graham Bell Picture Collection

5.0 HAULED-OUT

5.1 STEEL HULLED VESSEL: EXTERNAL

The extent of stabilization work required for a vessel that is dry-docked before refloating is more extensive than for a vessel that has been hauled out and is resting on a permanent framework or set of cribs. The person charged with the stabilization should first be satisfied that the supporting arrangement for the ship is sound enough to prevent unwarranted deflections of the entire hull. If necessary, the structural strength of supports and structure should be tested. Engage a reputable marine architect or testing consultant to check for concealed deterioration or other damage. If suspected, arrange for load tests.

Once the supports are approved, the hull should be given a thorough cleaning and loose rivets, plate seams and other deteriorated areas such as hull fittings, tail shaft and propeller made sound.

5.1.1 Internal and Weather Decks

The cleaning and the stabilizing of these parts of a ship is reflected in 4.1.1 above.

5.2 WOODEN HULLED VESSEL: EXTERNAL

As with steel hulled vessels, the extent of the stabilization work carried out while a vessel is dry-docked is not generally a requirement for a vesssel that has been hauled out and is resting on cribs.

The person charged with the stabilization should first be satisfied that the supporting arrangements for the wooden hulled vessel are sound. Work can then proceed on cleaning the hull, fastening loose or decayed fittings and correcting areas of deterioration.

5.2.1 Internal and Weather Decks

The cleaning and stabilization of these parts of a ship is reflected in 4.2.1 above.

6.0 SHIP'S RIGGING, FUNNELS AND GUYS

The cleaning and stabilizing of items referred to in this paragraph applies to either steel or wooden hulled vessels, hauled out or afloat.

6.1 RIGGING

Rigging has many wire shrouds and stays, metallic and non-metallic rope and fittings at the mast. With necessary safety precautions all metal fitting surfaces should be wire brushed to remove rust, flaking paint and other foreign matter. All metallic wire and fibre core that is not beyond superficial corrosion or has no broken strands should be given a suitable protective coating. Should the person charged with the stabilization work consider that the safety limit for securing the mast has been approached, then strength should be tested. A reputable, professional rigging testing consultant should be engaged to check out weakness in the entire rigging system. If suspected, arrangements should be made for the execution of stress tests.

Extensive rot in wooden masts should be removed by gouging out affected wood and shaping "V" slots to sound material. New wood then can be driven into the "V" shape slots and bonded to sound areas with epoxy. After curing, the new wood should be fashioned to conform to the original shape of the mast. It should be noted that this repair should be carried out in one area only. The next adjacent bad area should be excavated and renewed after curing of previous repair. To further extend the life of the mast, apply a chemical preservative treatment. Finish the mast with a suitable protective coating.

Main Shrouds, La Grande Hermine, Quebec City, PQ
Photo courtesy of A. Barbour

6.2 EXTERNAL: FUNNELS AND GUYS

The outer plating of the funnels should have all loose paint removed by wire brushing, light chipping or by chemical application. When sound cleaning has been established and deteriorated areas made good, apply a suitable protective coating to the complete outer plating of the funnels. From the funnel there are guy wire-ropes. All guys not beyond superficial corrosion or with no broken strands should be given a suitable protective coating. Should it be considered that safety limits have been approached, replace the guy with the same material. Apply a protective coating.

7.0 BOILERS AND MACHINERY

Regardless of the type of boiler, water or fire-tube, internal and external long-term preservation is generally an extended problem. Stabilization procedures for both internal and external cleaning are given below.

7.1 WATER TUBE BOILERS

7.1.1 Internal

Open air cocks, pressure gauge cocks and running down valves and verify that no pressure is left in the boiler. Remove manhole doors and wash out mud and sediment with a fresh water hose from outside the boiler. Ventilate boiler drums thoroughly with a portable fan. When satisfactory gas testing has been carried out one may enter the boiler. Wipe down the interior of drums with rags. Clean and scrape all parts showing corrosion. Clean out pitting. Wire brush the interior of drums and tubes. Remove all dirt and other foreign matter from the drums. Black lead and polish drums. Close all boiler mountings and cocks. Place small bags of silica-gel in the water drums in order to absorb moisture. Remake the manhole door joints with new gaskets.

7.1.2 External

Sweep down the funnel, uptakes and casings, working from the top downwards. Clean funnel rain drain pipes. With wire brush remove all loose scale and coat entire area with boiled linseed oil. Remove side panels and access register to the furnace, clean between the tubes, using flexible wire brushes. Clean panels of side casings and coat lightly with boiled linseed oil. Replace side casing panels. Put hot air blower in furnace. Remove all foreign matter from the machinery space. Save samples of all discarded material. The analysis of wasted matter could be important for documenting the history of the vessel and her boiler.

7.2 FIRE-TUBE BOILERS

7.2.1 Internal

Open necessary valves, air cocks and pressure gauge cocks and verify that no pressure is left in the boiler. Remove manhole and hand-hole doors and wash out mud and sediment with clean fresh water. Adjust water pressure as necessary to remove all deposits. See that all silt and other foreign matter is removed from the boiler and the boiler is clean. Dry out the boiler as quickly as possible using hot air blowers. Place small bags of silica-gel in water drum. Remake manhole and hand hole door joints with new gaskets. Close all boiler mountings, air cocks and drains.

7.2.2 External

Sweep down funnel, uptakes and casings working from top downwards. Clean funnel drain pipes. With wire brush remove all loose scale and coat entire area with raw linseed oil. Remove smoke box door and with wire brush thoroughly clean tubes, flues, firebox, tube plate and smoke box door. After the fire side of the boiler has been cleaned, these external components are to be given a coating of raw linseed oil. Box up the boiler and ship the funnel cover. Remove all foreign matter from the machinery space. Save samples of all discarded material. The analysis of waste matter could be important for documenting the history of the vessel and her boiler.

7.3 MACHINERY

For technical considerations in connection with long term preservation see Section 4.7 "Stabilization: Period Machines."

8.0 MAINTENANCE

For a standard format to be used in the preparation of maintenance manuals for historic sites and structures, see Vol. V.1.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

4.9

STABILIZATION

ARCHAEOLOGICAL SITES

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CONTENTS

1.0 INTRODUCTION

This article outlines the objectives and methods of stabilization for archaeological sites. It briefly describes basic technical procedures and cites some Canadian Parks Service (CPS) experiences in this area.

1.1 BACKGROUND

The saving of archaeological sites has been a concern of the heritage community for years. However the stabilization of sites, in particular ruins and excavated structural features, has only recently come to the fore. As the stabilization of sites is a new venture, the techniques and methods of design services used, are still experimental and often undocumented. Indeed, due to the great expense involved in most stabilization techniques, few heritage organizations have undertaken research into the field.

CPS is a leader in the stabilization of archaeological sites in Canada. However, in a global context, North American heritage organizations lag behind their European counterparts.

1.2 SCOPE

This article is intended for architects, engineers and others responsible for stabilizing historic sites and structures. It is also for staff preparing or administering consultant contracts for this type of design service.

2.0 DEFINITION OF AN ARCHAEOLOGICAL SITE

The 1979 Parks Canada Policy defines a historic structure as follows: "Historic structures are works of man, created to serve some human activity and are usually by nature or design immovable."

The Canadian Parks Service (CPS) interim policy on Cultural Resource Management (CRM) defines a cultural resource as:

> … a human work, or a place that gives evidence of human activity or has spiritual significance, and that has been determined to be of historic value… . The Canadian Parks Service may apply the term cultural resource to a wide range of resources in its custody, including, but not limited to, cultural landscapes and landscape features, archaeological sites, structures, engineering works and artifacts.

However, for the purpose of this article, the definition of an archaeological site is the ruins of historic structures or works, whether they are extant (above grade) or uncovered during excavation.

3.0 CONSERVATION OPTIONS

The different kinds of resources that need to be considered in a discussion of stabilizing archaeological sites are features which are in a state of ruin and are above ground, and features which are uncovered in the course of archaeological excavations.

Above-ground Ruins

This distinction must be made because, while structurally these resources may appear similar, they are not. The latter resources, uncovered in excavations, have reached a state of equilibrium with their burial environment, and they would not have been subject to the same environmental fluctuations as those ruins exposed to the elements. In uncovering these buried resources, the equilibrium is broken, causing renewed deterioration which, by its sudden impact, may cause a rapid deterioration in the materials and their stability.

Uncovered Ruins

The distinction between ruins and the foundations of structures can be a fine difference; indeed many of the methods and techniques used in building stabilization are not different from those used in the stabilization of ruins. Research to date on the construction, stabilization and conservation of masonry structures should be referred to within the context of other sections in this volume.

Why does one want to stabilize archaeological ruins? Aside from general policies regarding the protection of historic resources, we can itemize a number of specific reasons:

a. they may be the only extant evidence of an earlier historic structure;
b. they are non-renewable resources; once destroyed they can never be replaced;
c. they present an interesting interpretive technique, increasing public appreciation, understanding and enjoyment of these resources;
d. stabilization will assist the resource to 'stand' on its own longer;
e. to save the resource for the future when expertise will permit more precise recording and analysis of the resource; and
f. to assist in the preservation/restoration of the historic environment.

Archaeological ruins may be dealt with by

- stabilization
- restoration
- anastylosis (partial reassembly)

This article concentrates on the stabilization (sometimes known as preservation or conservation) of these resources. The term "stabilization" is defined as an effort to prevent further deterioration to maintain the existing form, integrity and material of historic resources (Parks Canada Policy, 1979, 2.0). CRM adds that stabilization (or preservation) involves the application of techniques designed to preserve and consolidate existing historic fabric for an extended period of time. It may take place selectively as part of a major property development program.

Levels of intervention which will affect the techniques used in the stabilization of ruins include interim stabilization or 'mothballing' in expectation of future development plans (whether they be short- or long-term plans) and development of the resource with the intention of long-term stabilization (where the preserved ruins are incorporated into the interpretive program for the site).

4.0 METHODS AND TECHNIQUES OF STABILIZATION

4.1 BACK-FILLING OF EXCAVATED AREAS

The most common method of stabilization for excavated archaeological sites is to back-fill with soil. Frequently excavation areas are filled with sand as it offers excellent drainage and is easy to re-excavate if required. Another common practice is to line excavation areas and to cover archaeological features with polyethylene sheeting. The polyethylene acts as a demarcation of depth and total area excavated, should the area be re-excavated. Further, the polyethylene protects features as the area is back-filled.

A number of conservation specialists have questioned the long-term success of polyethylene. In some circumstances moisture may be trapped below the sheeting resulting in damage to the resources. Polyethylene should be used with caution and only after site conditions are known.

4.2 NON-EXCAVATION

A form of stabilization, not often enough considered as such, is to leave the archaeological resource undisturbed. The artifacts and structural features have reached a state of equilibrium within their burial environment. Exposure to the elements upon excavation will only accelerate decay; hence the resource might be better protected if left untouched.

4.3 SOIL COVERAGE OF ARCHAEOLOGICAL RESOURCES

If the resource is to be left in the ground (as above), but may be disturbed, the area can be stabilized by covering it with soil so as to protect it from any possible disturbance. Several distinct layers of soil would be preferable to distinguish the original deposit from the subsequent fill. A layering of sand, topsoil and then sod would provide such a demarcation.

4.4 MASONRY STRUCTURES

The most common stabilization treatment for masonry features above grade is repointing. In addition, walls are often capped to prevent water penetration into the interior of the structure.

a. Walls should be cleaned of humus and kept free of vegetative cover. Otherwise additional plant growth will be encouraged, retaining potentially damaging moisture next to the masonry.
b. Exposed flat surfaces should be sloped to shed rainwater, to avoid damage from penetrating moisture.
c. Asphalt or epoxy resin* should be applied to flat surfaces to prevent water penetration.
d. Loose rendering should be removed.
e. Repointing should be done where necessary.
f. Deteriorating ironwork should be recorded and then removed to prevent staining and stresses caused by rusting.
g. Holes left in the masonry from the removal of wood beams should be filled with mortar to within 1-2 cm of the wall surface.
h. In anticipation of any future inspection, maintenance or repairs, non-corrosive anchorages should be placed in the masonry to attach scaffolding.

* Although Feilden recommends resin sealants for masonry surfaces, the practice is controversial.

The analysis and stabilization of St. Raphael's Catholic Church in St. Raphael's, Ontario, by CPS and the Ontario Heritage Foundation is an excellent example of the successes and problems encountered in a masonry ruin. This work is presented as a case study:

a. The structure, dated 1821, was destroyed by fire in 1970; all of the wooden elements were lost, while the stone mass remained standing;
b. In 1972-73 the Ontario Heritage Foundation spent $80,000 on the stabilization of the limestone walls;
c. The objective was to make an open outside room, to be used for special events and musical performances;
d. A new unobtrusive church was attached to the rear corner of the original structure;
e. Consultants from Parks Canada (J. Dalibard, M. Weaver) directed the work; the contract architect was S. Harvor;
f. The walls were completely repointed;
h. A double layer of protection was proposed for capping the walls:
   - the upper courses of stone were to be lifted, a layer of polyethylene sheeting installed, and the upper courses of stone replaced
   - the tops of the walls were to be capped with a mixture of asphalt and stone dust, creating a semi-circular crown to shed the water
i. Only the second layer of protection was used, as removal and replacement of the upper courses of masonry was considered to be too costly and troublesome;
j. The capping material has stood up well, although some cracking is evident on the tops of low interior walls to which visitors have access;

k. Two major problems arose from this stabilization work:
   - the upper courses of masonry which had originally been hidden behind the soffit and rafters had never been pointed: repointing these upper courses was not adequate, leaving the upper masonry unsafe
   - stone window sills did not originally project into the church; when it rained, the water would rush down the interior walls of the church, washing out the mortar for a distance of 1 m below the window. This washing could have been prevented by throwing the water off the wall by a projecting interior sill

l. In order to indicate structural movement, U-shaped glass 'tell-tales' were installed spanning joints in the upper reaches of the masonry; on inspection ten years after the stabilization, all of the glass rods had broken;

m. While cyclical maintenance and inspection was requested of the building's owners, no inspections took place until ten years after the stabilization (such inspections are important for a structure's long-term security);

n. Within the structure, an attempt was made to secure plaster surfaces in the apse of the church;

o. The plaster was pinned to the masonry with non-ferrous screws and plastic washers;

p. The plaster was edged with caulking to prevent water penetration between the plaster and the masonry;

q. The caulking, however, has failed, causing water damage to the plaster; and

r. A lime mortar would have been a preferable sealant, as it would have resealed the edges with each rainfall.

The stabilization of masonry surfaces with sealants is controversial. The objective of sealing masonry surfaces is to prevent water penetration into the masonry unit, the mortar and the openings between the unit and the mortar. Sealing the surface will, in theory, restrict moisture which would cause frost damage and salt crystallization.

Seldom, however, do sealants provide absolute protection from the elements. Indeed after sealing, water in the masonry units from rising damp is less readily lost by surface evaporation. Rather than hoping to prevent a problem, the masonry may suffer "from a clearly-defined fault that the treatment holds promise of correcting" (see Ritchie).

4.5 STABILIZATION OF SOILS AND INORGANIC FEATURES

Stabilizing the soil walls of the excavation area is still at an experimental stage. Ontario Region of CPS is currently experimenting with the following form of stabilization at Fort Malden. An excavation area of approximately 2 m^2 by 1 m in depth was to be left open for visitors to show the foundations from the 1796 Indian Department Storehouse. To stabilize the soil walls, a trench was dug behind two unit walls leaving a pedestal of soil 45 cm thick. Holes were bored vertically into this pedestal 12 cm from the interior soil face and an acrylic resin (Acrolyte B-72), dissolved in toluene was then poured into the pedestal. Polyethylene sheeting was tacked to the back of the pedestal to prevent moisture damage when the trench was back-filled. A display case is to be constructed over the area, allowing the visitors to look at the structural remains.

4.6 STABILIZATION OF ORGANIC STRUCTURAL FEATURES

Stabilization of soils in conjunction with organic structural features (wood) was conducted at Fort Walsh in 1979, at the 1875-83 North-West Police compound. The technique used involved pre-treating the area with a fungicide to prevent mold and fungus growth. A sealant of 625 g of Bakelite Vinyl VYHH resin dissolved in 4.4 L of acetone was used. The resin was sprayed in a continuous film onto the surviving structural evidence and the soils.

After five years the display was still intact, although some drying and distortion of the wood remains have occurred. Further, spring run-off caused moisture damage to the area, resulting in a discolouration of the resin (see Lunn and Murray).

4.7 PARTIAL REASSEMBLY

Partial reassembly of stone structures (replacing stones which have fallen off the structure) is also known as anastylosis. As a conservation practice it is best known for its early application at ancient period temples and other ruins. While it has potential, because of the degree of conjecture involved, it should be applied in an extremely limited and fully reversible fashion.

Archaeological ruins and features may also be stabilized and incorporated into a new building or structure. Because of the need for the ruins to act once again as functioning foundations, this approach can require a high degree of intervention. This practice has been used at some CPS masonry fortifications, canal works and industrial sites.

4.8 PROTECTIVE SHELLS

Archaeological ruins may be stabilized by covering them with a protective shell. This method is seldom used in North America, although it is more common on European sites.

One of the most prominent North American examples of covering archaeological features is at Franklin Court in Philadelphia: "Where there were some remains of foundation walls, privy pits, etc., the firm glazed them over, and built concrete hoods to shield the glass from the glare for viewing" (*Progressive Architecture,* p. 69).

Protective shells have been considered by CPS at Les Forges du Saint Maurice and La Redoute Dauphine, both in the Quebec Region. The development plan for Les Forges is included in its entirety as Appendix I. It presented various options for stabilization, including the recommended concept plan of a protective shell.

5.0 STABILIZATION EFFORTS IN CANADA'S NATIONAL HISTORIC SITES

Numerous examples of stabilized archaeological sites exist within Canada's National Historic Sites. Most of these stabilization efforts have involved repointing and capping of masonry ruins and foundations of 17th through 19th century structures. In recent years there have been additional experiments at stabilizing organic structural features.

CPS regional staff provided the information on the following projects. The data for each region is not complete, as stabilization efforts have seldom been formally documented in reports; the information is stored in office files and in the memories of project personnel, which seldom offer complete recountings of past events.

Lower Fort Garry, MB

5.1 PRAIRIE AND NORTHERN REGION

a. Lower Fort Garry, MB:
The foundations of an 1840 brewing complex were stabilized in 1968-69, including the brewery, a mill and a kiln. The stone foundations of these buildings were repointed and the area was back-filled with sand to permit good drainage of the site.

b. Fort Walsh, SK:
Organic elements of the 1875-83 North-West Mounted Police structure, were stabilized by the project archaeological staff. Experimental use of resin sealants on the excavated features is discussed in 4.6 above.

Fort Walsh, SK

5.2 WESTERN REGION

a. Rocky Mountain House, AB:
Site "1R" is the location of the 1865-75 Hudson Bay Company Rocky Mountain House, the last fort on the site. Two stone chimneys were reconstructed in the 1930s by local citizens and in 1981, the chimneys were repointed.

The site of the 1799-1835 Hudson Bay Company Rocky Mountain House is Site "13R." This site was excavated several times, the major work conducted in 1962. The last time it was excavated, the structural elements were accurately recorded, reburied and the features partially reconstructed above grade. Included in this 1981 stabilization were the bases of four stone fireplaces and the reconstruction of wooden sills and the first few log courses.

The site of the 1799-1821 Northwest Company Rocky Mountain House – Site "16R" – was excavated in 1981 and at the same time stone fireplace bases and partial fireboxes were repointed.

5.3 ONTARIO REGION

a. Fort Malden, ON:
Stone foundations of the 1796 Indian Department Storehouse were exposed in 1983. Experimental use of acrylic resin in the stabilization of the soils of individual excavation units was done by Conservation Services of the Ontario Region. See discussions above of techniques used and results.

b. Fort St. Joseph, ON:
As the centre for the fur trade of the British military and Indian Department in Upper Great Lakes – 1796-1814, excavation work was undertaken by the Sault Ste. Marie Historical Society in 1926. This involved repointing the prominent above-grade ruins including the powder magazine, a chimney and the 'new' baker. Excavations in recent years have uncovered the foundations of additional structures, which have been repointed and left exposed for public view, including the 'old' bakery, blockhouse, guard house, chimneys of the stores' building and military kitchen.

The walls of the powder magazine are approximately three-quarters extant; excavations exposed the footings of the structure below grade. However, structural faults in the masonry developed due to exposure to the elements. The trenches around the structure were therefore back-filled to original grade. Other foundations have had problems with moisture damage (frost action) to the mortar, resulting in the need for a variety of interim stabilization maintenance projects in past years.

In several instances the trenches excavated around the foundations by the archaeologists were left open, but roped off from the public. Some regrading adjacent to the foundations and trenches was necessary, while the soil walls of the trenches received no stabilization treatment or shoring. Park staff report no serious collapse of the soil walls.

Fort St. Joseph, ON

Les Forges du Saint-Maurice, PQ

The kiln structure was structurally unsound and there was a suggestion to dismantle and reconstruct. However, this option was turned down and the kiln was filled in and over with sand as a stabilization measure to prevent further collapse.

c. Royal Engineers' Building, Ottawa Locks, ON:
Located on the east side of the Rideau Canal adjacent to a composite retaining wall below (and north of) the Chateau Laurier, the stone foundations of this structure were uncovered in the early 1980s, the original construction dating to 1826-1911. The foundations were back-filled with sand and the walls capped with concrete; repointing was completed as necessary. A small wooden 'shed' with an asphalt shingle roof rests in the middle of the foundation, covering a brick furnace platform and drain.

The structure is on a raised plateau of land surrounded by a short iron fence and most public access to the structure entails crossing over a lock gate from the west side of the canal. A gate leads to wooden stairs which lead up the slope to a wooden platform overlooking the foundation from its southwest corner where the stone walls are visible. The capping of this archaeological site would appear to have been intended as a mothballing intervention, as no interpretive signs lead visitors to the platform. Further, the entire area, both surrounding and within the foundation walls, is overgrown with weeds, brush and saplings. This latter fact may be of some concern as the vegetation will hold moisture in the soils around the foundation increasing the likelihood of water damage to the mortar, stone, brick and concrete cap.

5.4 QUEBEC REGION

As discussed above, various stabilization and interpretive options have been presented for structural ruins in Quebec Region. Indeed, conversations with staff from each of the CPS regions suggests that the most innovative approaches have been suggested for Quebec. Most stabilized resources in Quebec, however, are masonry walls which have been repointed, grouted and/or capped.

With regard to masonry foundations and footings, Quebec Region staff present an interesting option in their stabilization program. In most instances, excavated masonry foundations are repointed during the course of the field season when they are exposed. Over the course of a field season, all too often, masonry foundations are weakened by their exposure to the elements, primarily by precipitation which leaches out the mortar. This option is particularly interesting as no discrimination is made in the repointing of foundations which will be left exposed for interpretation purposes and those foundations which will be reburied, quite possibly never to be unearthed again.

5.5 ATLANTIC REGION

a. Fortress of Louisbourg, NS:
Although the majority of the developed portions of this 18th-century site have been rebuilt or reconstructed, in recent years, some stone foundations and footings have been stabilized, some masonry walls have been repointed while others have seen pressure grouting.

b. Fort Anne, NS:
A French fort built between 1695 and 1708 and subsequently occupied by the British, where very little archaeological research has been undertaken. However, the site's

management plan calls for the stabilization and conservation of exposed structural features.

c. Fort Beauséjour, NB:
This French fortification built in the 1750s has seen the largest number of ruin stabilizations in the Atlantic Region. In most instances stone structures have been repointed and left exposed and some structures with extant complete walls, have had roofs replaced to protect interior masonry surfaces from the elements.

6.0 ICCROM INFORMATION SHEET

The recently published report *Conservation on Archaeological Sites* should be sought for information on international stabilization trends. It should also be noted that ICCROM aims to publish a newsletter on 'site protection, reviews of relevant literature and short reports on practical experience in the field.'

The proper conservation of finds made during excavations forms an integral part of archaeological research. Ideally, the excavation team includes a professional conservator who remains responsible for conservation throughout the project. Recognizing, however, that this ideal is rarely achieved, the papers in this article describe some basic principles of conservation in the field with which archaeologists should be familiar. They are concerned with procedures to follow before, during and after excavation for the conservation of both movable objects and architectural remains.

Contents:

- Excavation and conservation – N.S. Price
- The role of the objects conservator in field archaeology – K. Foley
- Object interred, object disinterred – G. de Guichen
- First aid treatment for excavated finds – C. Sease
- On-site storage of finds – G. Schichilone
- The site record and publication – J. Coles
- Protection and presentation of excavated structures – J. Stubbs
- Conservation of excavated intonaco, stucco and mosaics – P. Mora
- Protection and conservation of excavated structures of mudbrick – A. Alva and G. Chiari
- Planning and executing anastylosis of stone buildings – D. Mertens
- Conservation on excavations and the 1956 Unesco Recommendation – N.S. Price.

7.0 CANADIAN PARKS SERVICE SITES

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8.0 APPENDIX

National Historic Park. Les Forges du Saint-Maurice Development Concept

Parks Canada Parcs Canada

Introduction

Les Forges du Saint-Maurice: national historic park

Les Forges du Saint-Maurice National Historic Park was created in 1973, following the signing of an agreement between Canada and Québec. Located north of Trois-Rivières, the site contains the vestiges of the first Canadian industrial establishment based upon the exploitation of non-renewable resources.

For over five years, Parks Canada has been engaged in research which has resulted in a greater understanding of the site and helped define its potential.

A development concept was recently proposed indicating how to preserve the resources and make best use of the site's potential for the benefit of present and future generations of Canadians.

The Context

The historical background

The creation of Les Forges du Saint-Maurice dates back to 1730, when the rights to exploit the iron-rich savannahs in the Trois-Rivières region were granted to a Montréal merchant, Poulin de Francheville.

A number of site characteristics explain the location of Les Forges:

• its proximity to surface iron-ore deposits that were easy to mine, a type of forest cover suitable to the production of charcoal, and limestone as well as sandstone deposits;
• the presence of a stream with sufficient flow to satisfy the energy needs of the industry;
• the ease of moving finished products from Les Forges to Trois-Rivières via the Saint-Maurice River.

The exploitation of Les Forges du Saint-Maurice which spans a period of more than 150 years represents an original segment of Canadian history, in that this enterprise, based on the transformation of iron ore, developed in an economy centred essentially on the fur trade, lumbering and agriculture.

Under various administrative regimes, directors, forge-masters, foremen, semi-skilled workers, craftsmen and apprentices, came and went along with their families; seasonal workers, living in the neighbouring region, also contributed to the work being done. Utilizing the techniques of the day, all participated in varying degrees in the manufacture of many different products, dictated by the prevailing economic and political conditions.

Historical and archeological research

Today, almost a century after the establishment closed down, historians and archeologists have begun to research the past; archives, old illustrations, and the vestiges themselves are slowly but surely revealing an impressive amount of information about the multifaceted social, political and economical history of the first Canadian ironworks industry.

The vestiges excavated by the archeologists are linked to both industrial and habitation themes.

The industrial theme is mainly centered on the vestiges of three structures linked to the production of cast-iron (the blast furnace, the upper ironworks - new forging furnace unit and the lower forge), which are located along the axis of the stream. This theme also includes the finishing shops located on the plateau, as well as various works related to the processing of raw materials. As to the habitation theme, it includes: housing, domestic life and service buildings.

When the archeological research, now in its final phase, is completed, some 60 structure and buildings will have been identified and the most significant vestiges will have been excavated.

The objectives of the park

The objectives of Les Forges du Saint-Maurice national historic park were determined after evaluating the potential of the different resources, while taking into account the policy adopted for national historic sites, the historical reasons for the park's existence, its integration within the Canadian national historic park system and its regional context. These objectives are defined as follows:

• to preserve both the historical vestiges associated with the activity of Les Forges over a period of 150 years and the historical elements in the natural environment;
• to exploit the potential of the site in such a way as to

commemorate the "milieu," the people and the activity over a period of 150 years of the first Canadian industrial village;
• to actively participate in animating the sociocultural development of the region.

Options for developing the site

Considering the nature, conditions and potential of the site resources and in keeping with the objectives, a task force has been studying three options which could form the basis of a development concept for the historical area of the park, namely:

• an open exposure of the vestiges as found;
• the restitution of historical structures associated with the reconstitution of the historical landscapes;
• the creation of symbolic structures associated with the redevelopment of the historical landscapes.

Option 1:
An open exposure of the vestiges

The first option emphasizes the permanent stabilization of the most significant site vestiges and their protection against the elements. Such stabilization is, in this case, considered as both a means of preservation and a means of exploiting the potential of the site.

As the environment would be landscaped in a contemporary style, the relative starkness of the site would necessitate the construction of an interpretation centre located outside the historical area.

This option would therefore transform the historical area of the park into an archeological site similar to other well-known North American and European examples.

The open exposure of the vestiges offers certain advantages:

• it would prove an economical solution since the work on the structures would be kept to a minimum, thereby reducing operating and maintenance costs;
• this option would also permit the exploitation of the authentic historical vestiges as an integral part of the village.

However, this option presents three major drawbacks:

• the protection required against the elements and erosion might mask the authentic character of the vestiges;
• this option also entails a series of interpretive constraints:
  - the need to resort to lengthy and elaborate explanations in order to relate both the evolutionary dimension and the industrial character of the site;
  - the difficulty for the visitor to grasp the relationship between what he sees on the site and what is presented at the interpretation centre;
  - the possible confusion to perceive the spatial relationship of all the elements on the site, because of an overlay or juxtaposition of vestiges belonging to different periods;
• finally, an open exposure of the vestiges creates very little visual impact and might prove disappointing to visitors.

Option 2:
The restitution of historical structures and landscapes

The restitution of historical structures aims at recreating some of the original aspects of the most significant of these, using contemporary techniques and materials, after first stabilizing their vestiges. This is a much more sophisticated approach than open exposure. The environment would be landscaped to suggest the atmosphere of the period.

This second option offers several interesting advantages:

• it would give the site a very striking appearance by creating a dynamic attraction;
• this option would permit the use of the authentic vestiges and allow to some extent for the direct application of the historical and archeological research;
• this option also promotes a more dynamic and better balanced interpretation program, including sheltered interpretation units, more efficient grouping of the visitors, clearer visual perception, elimination of the "interpretation centre," and more and better means of communication;
• finally, by adding a single structure, the protection of the vestiges against the elements would become much less of a long-range problem.

However, this option also presents some serious drawbacks:

• the restitution of structure would entail considerable expense;
• there is also the risk that the visual impact of the authentic vestiges would be overshadowed by the restored structures; in addition, creating a landscape with is "too new" and too artificial risks giving a false impression of the site.
• Option 2 is tied to a particular historical period which, in turn, is based on specific forms and models as well as on the functions of the buildings to be restored. This freezing in time is not desirable at Les Forges since one of the objectives of the project is to give equal treatment to the entire 150 years of activity in the industrial village, while respecting the evolutionary character of the site.

Moreover, the selection of a specific-period necessitating the back-filling of earlier or later vestiges, would likely render the structure unintelligible and would deprive the site of certain authentic resources.

The selection of a specific period in time could itself pose a problem. In fact, must one specific period be chosen for each structure to be restored? Should the chosen period necessarily be the most significant for each structure? And conversely, might not the restitution of historical volumes over different periods risk confusing the visitor?

At the outset, it was decided that if the 150 year evolution of the industrial village was to be respected, rebuilding or restoring the entire historical area in its original form would not be feasible.

This type of restoration is now viewed as a traditional way of developing and interpreting an historical site, but its efficacity must be questioned in that it often reduces the visitor to the role of a mere spectator, wandering through an artificial "museum-like" setting. Often, too, such attempts to provide a certain "atmosphere" fail to respect the true historical realty.

Option 3:
Creating symbolic structures within the historical landscape

In some ways, the third option is quite similar to the second; it proposes building a contemporary structure, which would describe the character and function of the original building, over the stabilized vestiges. The environment would be landscaped in such a way as to symbolically depict the overall panorama of the entire 150 years of industrial activity on the site.

In general, this hypothesis offers the advantages of the preceding option, namely:

- significant physical impact,
- exploitation of the authentic vestiges,
- original and dynamic ways of interpretation,
- adequate protection of the vestiges.

The particular advantages of this option:

- Option 3 would respect the evolutionary character of the site by utilizing architectural structures which could symbolize the different functions and activities characterizing given buildings without being tied to a particular historical period;
- this option seems the most complete and the most satisfactory for preserving and interpreting the vestiges since the structures would protect each excavated vestige on its original site;
- resorting to the use of symbolic structures favors a remarkably flexible development sequence. Because of the different architectural forms and the contemporary materials utilized, it should be possible, over the years, to modify or eliminate certain elements without destroying the overall appearance of any one structure.

Yet, this option entails several drawbacks:

- the relatively high building costs;
- the risk that the impact of the authentic vestiges will be masked by the symbolic structures;
- the restored site would not correspond exactly to what Les Forges looked like throughout its history.

The Concept

Guided by Option 3, the proposed development concept for the historical area of Les Forges du Saint-Maurice is four-tiered, involving:

- the stabilization of the most significant or best preserved vestiges on the site;
- the addition of a symbolic structure on top of these privileged vestiges;
- the preservation of the other excavated vestiges with suitable on-site interpretation;
- the redevelopment of the historical landscapes.

Stabilizing the vestiges

The permanent stabilization of the most significant and best preserved vestiges on the site will enable visitors to see them and have them explained. The following structures may be classified as having significant and well-preserved vestiges:

- the "haut fourneau" complex;
- the "forge haute - fourneau neuf" unit;
- the "forge basse" and the "maison des forgerons";
- the "grande maison";
- a group of structures once utilized for habitation and services.

Adding symbolic structures

A symbolic structure will be added to each of the privileged vestiges on the site. These symbolic structures will depict both the character and function of the historic buildings in order to project the image of both a village and an industry. They will respect the evolutionary character of the site and offer a broad spectrum of possibilities for exploiting the vestiges while ensuring their constant protection.

The architectural characteristics common to all the structures illustrated here endow them with highly functional characteristics. The use of low platforms would serve both the need to protect the vestiges and permit their interpretation, while the three-dimensional nature of the structures would symbolically

recall the form or the function of each original building. This is also an economical solution as it is not necessary to heat such structures in the winter.

The platform would cover the entire area occupied by each vestige and permit its preservation within a controlled micro-climate; the space created would be sufficient to allow installing interpretation modules.

The interior of the industrial structures at Les Forges was dark and noisy, pierced by flashes of light coming from the fire or from the hot melting metal; the spaces below the platforms will attempt to recreate this atmosphere. In the summer, different interpretive equipment could be located on the platforms and would provide added interest.

The project for developing the structures proposes to recreate certain elements, such as walls, chimneys, machinery ... which would suggest the activity of Les Forges, by utilizing silhouettes, profiles or transparent surfaces. These effects are obtained by recourse to a three-dimensional structure which creates abstract transparent shapes whose light and airy forms will inspire the visitor to imagine what the site looked like originally.

These transparent silhouettes will also enable the visitor to perceive the surrounding landscape through the stylized structures, thereby creating a simultaneous indoor/outdoor relationship. The three-dimensional structure could also serve as scaffolding to which different elements (such as theatrical scenery) might be added to establish a link with the past.

Preserving the vestiges

The back-filling of all the other vestiges unearthed during the archeological research has been recommended to ensure their preservation.

However, this does not mean the buried vestiges or the numerous buildings which once occupied the site should be forgotten.

Thus, it has been proposed that simple and low-cost techniques for marking the presence of these hidden vestiges and highlighting the dimensions of former historical structures be examined.

Redeveloping the historical landscape

Redeveloping the historical landscape is a concept which emphasizes the preservation of the actual historical elements within the environment and proposes that other elements in the landscape be developed in harmony with the symbolic structures to be erected on the site. This implies the development of the environment along contemporary lines, as far as treatment is concerned, while respecting the historical integrity of the site. Thus, today's pedestrians will follow the same paths as their counterparts of yore, but refurbished for modern use. Contemporary landscaping techniques will give symbolic life to the flower and vegetable gardens, the fields and orchards of a day long past.

In order to comprehend every aspect of the industrial activity at Les Forges, it is necessary to understand the use of the natural resources as a source of energy. Thus, exploiting the potential of the stream assumes an important role. The development concept of Les Forges stresses the need to give the stream the functional character that it once possessed by restoring the stream's harnessing devices and canalization system. Redeveloping the stream as a living element of the past would also breathe life into the symbolic structures and give real meaning to the notions of industry, force and energy which these attempt to depict. Such redevelopment will also reanimate the industrial axis of the ravine by restoring the link that forged the industrial entity, which in turn explains their productive functions and justifies the location of the site. Finally, this redevelopment project will permit the exploitation of the waterway's energy potential by reactivating the restored or simulated machinery inside the structures.

In addition to the development of the historical site per se, the park will be equipped to provide essential services before it is opened to the public:

• access to parking areas located on the periphery of the historical site will be provided;
• a reception centre will supply information to visitors enabling them to become acquainted with both the site and the seasonal activities program;
• natural outdoor areas will be open to visitors who want to relax or take a picnic lunch in an attractive setting;
• finally, a scenic path will cut through the wooded embankments along the shores of the Saint-Maurice River; visitors taking this path will discover many interesting sights and enjoy the splendid views of the river and the opposite shore.

The Interpretation Program

Interpretation

Essentially, historical interpretation is a process of communication which utilizes experiments, objects and the appropriate media to explain and give meaning to phenomena or events which occurred in a given situation in the past.

This type of interpretation should be viewed not as a passive means for transmitting historical information, but rather as a

dynamic medium – an invitation to the visitor to relive and understand the past, to grasp the real meaning behind the evolution of an historical site.

Interpreting the site, Les Forges du Saint-Maurice: Approaches and Objectives

The guiding principle behind the interpretation of Les Forges du Saint-Maurice is to afford the visitor an opportunity to appreciate the many facets (geographical, technological, social, economic and political) which animated this former industrial village throughout its 150-year life span.

Although the park's national character will no doubt attract visitors from every part of Canada and elsewhere, the interpretation program will accord particular attention to the population of the Trois-Riviéres region, rightly viewed as the park's privileged "clientele."

Within this context, the interpretation program and its related activities will be structured to provide each category of visitor (schoolchildren, families, adults, elderly persons...) a clear understanding of the on-site elements presented in ways that have been carefully adapted to the interests, needs and expectations of these visitors.

In keeping with this policy, various approaches will be adopted, each one seeking to diversify the visitor's levels of perception and comprehension, for example:

- the sensorial level (that which pertains to sensory perception; ex.: participation);
- the emotional level (that which pertains to emotional perception; ex.: evocation);
- the intellectual level (that which pertains to both intellectual perception and knowledge; ex.: demonstration).

According to the type of approach selected and influenced by the nature of each "target group," the interpretation program:

- will afford the school clientele an understanding and/or utilization of the site in a way that will actualize the dynamic aspects of teaching regional history, thus encouraging students sense of discovery and their desire to learn more about the traditional values of their ambient milieu;
- will provide adults with information aimed at stimulating reflections on the historical and contemporary realizations of this patrimonial site; the program will also promote their delving further into the subject and hopefully, their intervening within their own milieu to protect cultural assets;
- will encourage elderly persons to rediscover and better understand their heritage, making them proud of their region by having them participate on an equal footing along with the other visitors in the efforts to preserve and develop their common patrimony and by encouraging them to visit other historical sites;
- will enable families to learn about their regional heritage which, in turn, will favour an exchange of information and a sharing of experiences between parents and children within surroundings which offer both leisure activities and an opportunity to relax;
- will stimulate the interest of all the other groups by having them actively participate in the development of the regional patrimony.

Themes and interpretations units

The history of Les Forges du Saint-Maurice is relatively complex and there are numerous themes which could be treated. This is one of the reasons why it was decided to have the interpretive themes deal with the site as a whole, linking these directly with the original function of each structure.

Thus, several "entities" or "units" will be set up to house the interpretive materials.

The themes linked to the industry will be interpreted at the "maison des forgerons" contiguous to the "forge basse" and witness to the earliest period of industrial activity at Les Forges. Here, visitors will have a glimpse of the difficult conditions of that era as well as how domestic life was organized. They will also be able to learn about the process of direct reduction utilized by Francheville to produce cast-iron:

- at the "haut fourneau" complex, divided into four interpretive subunits:
    - the "haut fourneau" itself;
    - the "halles à charbon";
    - the "mouleries";
    - the "logement du fondeur";

the accent will be placed on the earliest period of the iron and steel industry, a time when technology was still in its infancy. The process of indirect reduction and the various stages for producing and transforming cast-iron will also be explained;

- at the "forge basse," visitors will learn about the production of cast-iron and the smelting process;
- at the "forges haute - fourneau neuf" unit, visitors will be able to trace the industrial and technological evolution of Les Forges.

The social and economic dimensions of the village – grouping several themes will also be interpreted:

- at the "Grande Maison," the administrative seat of the industry, visitors will see interpreted, among other aspects, the functions of the building, its architectural characteristics, its

social symbolism and its spatial organization;

• within the area linked to habitation and services, visitors will learn about the social organization of the industrial village, the domestic and familial organization, the economy, education, religious practices, leisure activities, etc.

At the "boutique du forgeron," part of this same complex, the visitor will see interpreted the iron-smith's actual role at Les Forges, his duties, his living and working conditions, his participation in the economic life of the village as well as the material organization of an iron-smith's shop... .

The multifunctional centre

In addition to the interpretive units installed within the area of the authentic on-site vestiges, the interpretive program will also play an important role in the multifunctional centre situated at the entrance to the historical heart of the park. The themes developed here will relate to the comprehensive history of the industrial village, to the context that gave the village life, that saw it thrive and then decline, and to the geographical setting that sheltered it. These themes will serve essentially as an introduction to the site.

Moreover, since it is clear that developing the structures will meet but a few of the population's needs, we are studying the possibility of setting up a multifunctional room where visitors will meet to discuss their various group experiences within the framework of pedagogical and sociocultural activities (informal lectures, projection of audio-visual documents, exhibitions...) .

Along these same lines, we are also considering the possibility of placing the entire documentation, both written and audio-visual, relative to Les Forges and which has been compiled over the years, at the disposition of researchers, students, professors and the "curious." This documentation centre, set up inside the multifunctional building will include reference documents on the various aspects of the history of Les Forges du Saint-Maurice, on the history of cast-iron and the iron and steel industry in America, on the archeological research at the site and on the various works and studies which have led to the organization of the park.

To the sheltered interpretive units, described above, will be added the interpretation program relative to the stream (basins, canalizations, mechanisms...) as well as the interpretation of the surrounding landscape.

Moreover, as we are seeking the maximal development of the originality and evocative power of the symbolic structures, we are now examining the possibility of offering visitors of all ages an on-site "sound and light" production, a contemporary representation of a past where every day hammers clanged and sparks flew.

Conclusion

Because of its original concept and special treatment, Les Forges will represent a unique element in the network of Canada's National Historic Sites.

Once completed, the symbolic structures will set a precedent for the restoration and reanimation of an historical site, a precedent that will bear witness to a high level of creativity, aimed above all at awakening the sensitivity and imagination of each and every visitor.

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1. Control of organic growth 1.
2. Control of organic growth 2.
3. Rough racking.
4. Gypsum plasters.
5. Mortars.
6. External renders.
7. Limewash.
8. French limestones for UK.
9. Glass reinforcement.
10. Clay products.
11. Rising damp.
12. Earth floors and lime concrete.
13. Lime ash floors.
14. Grouting.
15. Stone preservation (Brethane).
16. Timberwork.
17. Pointing.
18. Bronze.
19. Wrought iron.
20. Cast iron.
21. Lead.
22. Stainless steel.
23. Masonry cleaning.
24. Atmospheric pollutants.
25. Asphalt and bitumen.
26. Masonry repair and reinforcement.
27. Cob and pise construction.
28. Structural defects.
29. Paint systems.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

5.1
REHABILITATION
DESIGN STANDARDS

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CONTENTS

1.0 INTRODUCTION

This article identifies design criteria to be considered in the rehabilitation of historic sites and structures. It is not intended to provide detailed technical options for rehabilitation, but instead to suggest a context for design. Such a context is necessary for evaluating the ever-increasing amount of technical information in the rehabilitation field. Intended for professional and technical staff and members of interdisciplinary project teams, the following applies to all rehabilitation projects carried out on historic sites and structures.

2.0 DEFINITION

Rehabilitation is the upgrading of existing physical resources to satisfy new user requirements. Resources may range from small gardens, buildings and engineering works to entire urban districts.

At a purely utilitarian level, the physical modifications involved in rehabilitation can be based solely on a technical assessment of existing site conditions such as, in the case of buildings, floor and room areas, structural load capacities, means of egress, condition of the building envelope and mechanical/electrical system capabilities. These conditions can be modified to meet new technical requirements and applicable regulations.

However, good rehabilitation design must also understand the surviving assets in a historical and cultural context. These qualities could include integrity of style; unusual or significant spatial sequences or layouts; important patterns of functional organization; distinctive finishes and decorative features; and harmony of scale, texture and proportion. They might also include association with important persons, places or events. Together these qualities provide additional essential information for design modifications.

Rehabilitation, unlike period restoration, seeks contemporary design solutions rather than trying to recreate an earlier appearance of the site. The existing physical resources in a rehabilitation project can be treated simply as an intricate "built" landscape within which a new physical environment must be created. At this level, rehabilitation design parallels many aspects of normal contemporary work. However, their historical and cultural significance are also taken into account. Rehabilitation can share, with period restoration, the potential for preserving and enhancing a cultural heritage.

3.0 PREDESIGN REQUIREMENTS

3.1 GENERAL CONSIDERATIONS

A good information base must be established before design can begin. The base should have two elements:

a. a historical perspective, providing an overview of the site's development, with an assessment of surviving architectural and cultural assets; and

b. a physical perspective, providing a detailed technical assessment of current physical conditions on site. If both elements are not considered, rehabilitation can be unnecessarily costly and can destroy architectural and structural integrity.

Although this article deals primarily with historic structures, all such structures exist within and help define, historic landscapes. Predesign research, therefore, should establish a historical and physical perspective of the site as a whole. To co-ordinate the various disciplines involved in the analysis or predesign phase, the project manager should develop terms of reference in accordance with Vol. III.2 "Determination of Scope."

3.2 HISTORICAL PERSPECTIVE

Rehabilitation does not require the exhaustive documentary research needed for accurate restoration. However, any modification of historic sites or structures should proceed only with awareness of the historical, architectural, structural and environmental aspects of the site that were important during construction or that later became significant. Research should also document physical evidence of the site's history before it is modified by rehabilitation.

For general purposes, the following information should be established through on-site investigation and documentary research:

a. A breakdown of the site's physical evolution into important phases, based on changes to the physical configuration.

b. For each phase:
   - a reference, where evidence exists, to those responsible for the construction or modification defining the new phase and to their design intentions at the time;

- an assessment of architectural or landscape integrity and style, including relationship to setting;
- an indication of overall layout, including circulation patterns and functional organization;
- an indication of general structural configuration and of any unusual structural features or important alterations;
- an identification of mechanical and operating systems peculiar to the phase; and
- a summary of decorative finishes and detailing, including typical moulding and decorative profiles, patterns of ornamentation and evidence of colour schemes; for landscapes, a summary of decorative plantings, materials and features.

c. A summary assessment (based on the above information) of the important surviving architectural, structural and environmental assets. Important cultural associations that may enhance the remnants of a particular phase should also be referenced.

On most historic sites, some form of archaeological survey should be co-ordinated with the predesign phase. This survey can provide valuable information on the physical and functional evolution of the site, thus contributing to an accurate historical perspective. It can also help establish existing subsurface conditions. In many instances, an archaeological survey is required by law to salvage information and artifacts that might otherwise be destroyed during construction.

Structural Deterioration
Dawson, YT

3.3 PHYSICAL PERSPECTIVE

Because structural conditions and the overall extent of physical deterioration are critical to a project's economic viability and to the ability to maintain historic integrity, a clear physical perspective is needed before detailed designed options can be evaluated.

Physical conditions require careful on-site investigation. Such investigation often involves continual compromise between the need for extensive probing and the desire to protect surviving historic material. (See Vol. I.4 "Protection of Historic Fabric.")

The following information should be assembled:

a. a breakdown of the site or structure into major design categories such as subsurface conditions, site utilities, foundations, major and minor support systems, infill systems, openings, finishes and hardware; or, for landscapes, categories such as circulation network, boundaries and enclosures, grades, water features, plant material, structures and accessories;

b. for each category:
   - an assessment of current physical condition identifying areas of deterioration
   - an analysis of the causes of deterioration
   - possible remedial solutions

c. a summary of the major problems, roughly classed as structural, architectural, environmental and operational, with their implications for design;

d. a descriptive analysis of all surviving mechanical and electrical systems and other site services, with an assessment of their potential for reuse; and

e. a report, by a competent fire protection engineering professional, describing the fire protection features and fire hazards of the property and evaluating them in terms of regulatory requirements.

For detailed information on the techniques of analysis for establishing both historical and physical perspectives, refer to Vol. III "Historic Site Analysis."

3.4 DOCUMENTATION

Information gathered by Architecture and Engineering Services (A&ES) staff and other team members during the predesign phase should be assembled in a project dossier. The as-found records and other site documentation not only provide the basis for design and construction but also constitute an important archival record of wider significance for historical and comparative study.

4.0 DESIGN

4.1 GENERAL CONSIDERATIONS

The project brief initiates the design phase. It should summarize the predesign information and outline the new program requirements for the site. Program requirements are best developed in terms of functional relationships and approximate space requirements. New patterns of use can then be progressively matched to current or past ones.

Using the project brief as terms of reference, design can begin, usually by examining these five variables:

a. use and occupancy;
b. spatial organization and layout;
c. finishes and decorative features;
d. structural design and detailing; and
e. mechanical and operating systems.

Although these variables impinge on each other and frequently have to be considered concurrently, they represent components that can often be modified independently. Before discussing them individually, note the following regulatory requirements common to all five.

4.2 REGULATORY REQUIREMENTS

The National Building Code, National Fire Code and Fire Protection Engineering Standards apply to both new construction and the alteration of existing buildings. The word "alteration" is further defined here to include changes in physical form and in occupancy. Most rehabilitation projects are clearly within the scope of these regulations and the impact of these code regulations must be recognized from the start of any design process. (Some cities have begun to issue "preapplication permits" to underscore the importance, particularly in rehabilitation, of early contact with building officials to discuss regulatory issues).

Regulations have been developed to ensure an appropriate match of user groups to various physical environments. Compliance is usually most difficult where a new use is being forced on a built environment which has been poorly analysed for compatibility. Serious problems with the regulations may indicate problems as much with the design as with the regulations themselves.

Often, regulatory-related problems are expressed prescriptively rather than as performance objectives. This may make compliance unworkable. The only recourse now in most Canadian localities is direct negotiation with regulations officials and appeal boards to meet life safety objectives through design trade-offs. Compliance alternatives, to be used when dealing with existing buildings, are gradually being added to national and provincial codes. Specific areas of regulatory impact are identified below for each design variable.

4.3 USE AND OCCUPANCY

Insofar as possible, rehabilitation projects should not alter the original use of a property. Continuity of use is important to preserve the integrity of the structure as a design object and as it relates to its cultural environment. Specific technical advantages have already been mentioned with respect to regulatory compliance and there are often more general functional benefits from revising existing circulation and spatial patterns.

Where a traditional occupancy cannot be maintained, one compatible with the existing site assets should be found, as documented in the predesign phase (see 3.0).

In terms of regulatory restrictions for such design factors as numbers of exits, distances to exits, floor load capacities and allowable construction types, the various National Building Code occupancy classifications may be ranked in roughly the following order, each step down representing progressively more stringent design controls:

- business/personal services
- residential
- mercantile
- assembly
- industrial (low and medium hazard)
- institutional
- industrial (high hazard).

Not all regulatory requirements relate to this order and most historic structures predate standardized regulatory applications.

As a rule of thumb, however, an upward move is more likely to be adaptable to the existing facility than a downward move.

If a horizontally layered, multiple occupancy use is being introduced into a historic structure, occupancies with fewer regulatory restrictions and life safety requirements (higher up on the preceding list) should preferably be allocated to upper levels.

4.4 SPATIAL ORGANIZATION AND LAYOUT

The patterning of space is the basic purpose of architectural and environmental design. These patterns are experienced as spatial images and sequences organized by a network of pathways and nodes. Spatial arrangements on individual historic sites both functionally and visually provide significant information about earlier aesthetic ideals, social patterns and cultural assumptions. Attitudes toward spatial patterns often evolve slowly and are frequently used to define architectural styles.

In rehabilitating historic sites and structures, this aspect of their heritage must be respected. Necessary changes should be controlled, where possible, to enhance existing patterns or to re-establish earlier ones. Four major kinds of changes are frequently required, either alone or in combination: new external volumes; modified external circulation patterns; modified internal circulation patterns; and modified internal volumes.

4.4.1 New External Volumes

New external volumes, when required to provide additional floor space or means of egress, should be distinguishable from the rest of the historic structure to which they are attached, but related in massing and proportion to established design patterns. Connections to an existing building should be made at points which reinforce historical patterns of internal circulation while considering the effect on external circulation and the overall historic landscape. In some cases, the volume of a missing historic element can be reproduced. In other cases, successful earlier additions may provide design clues about natural growth patterns for that site. In general, new volumes should be subordinate in appearance and placement.

4.4.2 Modified External Circulation Patterns

Modified external circulation patterns may result, as indicated, from new external volumes. They may also be affected simply by new patterns of access to a site or an individual structure.

The access to a space is often a carefully thought out, controlled sequence of elements such as entrance gates, driveways, walk-

Early 20th century Wood Clad Residence
Courtesy of The Old House Journal, Gloucester, MA

ways, stairs, porches, doorways and lobbies. Historical patterns should be studied and preserved, where possible or recognized in contemporary design options. Visually, the entry and circulation should be easily recognizable and should reinforce the intended orientation of the structure within its own site and environment. Functionally, the access should reflect past practice where possible. If a traditional approach by foot has been replaced with vehicular access, the transition from the vehicle to a building or garden becomes an important design concern and should still be conceived, as with the pedestrian, in terms of properly orienting the visitor to the site.

Much of the actual control for external circulation patterns falls within the scope of landscape design and preservation. This aspect of rehabilitation should be recognized as interdisciplinary and as an important point of contact with wider urban or rural landscape preservation concerns.

4.4.3 Modified Internal Circulation Patterns

Modified internal circulation patterns may evolve from changed entry points or simply from new internal use patterns. As with the entry sequences, internal layouts should be studied before alterations are proposed.

In contemporary design, functional separation within a single occupancy or between various occupancies is usually horizontal. In the past, separation into adjoining vertical units was also common. Such an arrangement should be reused, where possible, if evident in the building's evolution, particularly if the basis for adequate vertical fire separations or complete fire walls is already in place. Large open staircases often emphasized this vertical circulation. Full reuse may be impossible within life safety restrictons but a remnant can often be preserved intact, such as an open well linking the first and second storeys where its relation to the entry sequence is least obvious. The entire shaft, particularly if skylit, can also be enclosed within new fire separations containing enough glass to sustain visual connection at each floor.

Other devices related to the sizes and proportions of lobbies and passageways were used to control the progression from public to private space. They should be exploited, where possible, and recognized in new layouts. New elevators, fire stairs and washroom facilities should be located to reinforce existing pathways, although the elements themselves may be distinguishable from the surviving historic fabric. As with external changes from pedestrian to vehicular traffic, internal shifts from period staircases to modern elevators should enable elevator users to experience the spatial organization originally designed to give coherence to the building.

4.4.4 Modified Internal Volumes

Modified internal volumes may be needed because of program requirements for desired sizes and interrelationships. Where possible, new functions should be matched to existing spaces, especially if various room sizes are available.

Before any substantial structural changes are made, bay sizes should be established in relation to structural support systems and modulations on the building exterior. Existing room proportions should also be analysed for typical height-to-width-to-length ratios and for the placement of openings.

Where enlargements are made, remnants of removed partitions may be maintained as framed openings, particularly if adjacent bays are interconnected. Where subdivisions provide smaller spaces, a sense of the original scale can often be retained by using less-than-full-height partitions for horizontal separation and partial mezzanines for vertical subdivision. Subdividing window openings with new construction must be done carefully, however, because of the impact on external appearance (particularly at night) and because of the importance historically of relating the proportions of window openings to the scale and function of the interior space they serve.

4.5 FINISHES AND DECORATIVE FEATURES

A designer uses finishes and decorative features to supplement and reinforce spatial patterns. In rehabilitation, it is important to recognize the historical relationships between these design aspects and to provide continuity in the contemporary design adaptations.

For exterior finishes, priority should be given to stabilization and preservation of the historic fabric. In many cases, structural materials were exposed, revealing information about structural design, as well as the purely visual aspects of facade composition. This exposed surface must be maintained as such, with repointing, repair, non-abrasive cleaning and weatherproofing as necessary. In other cases, a veneer was part of the original design, as in the use of stucco over brick. If such veneers are removed, not only is one left with an unintended appearance but also with uncovered material that may have poor weathering qualities. The veneer itself (whether of paint, stucco, terra cotta,

wood, sheet metal or other material) should be repaired and preserved or replaced in kind to the same scale and texture of the original. In some cases, an earlier surface is evident behind later veneers and there may be the opportunity to return to an authentic period appearance. If a replacement finish of different material is necessary, attempts should be made to match width, profile and surface characteristics of the new to the old.

Exterior decorative features, such as porches, balconies, door and window surrounds, vergeboards, finials, dormers, cupolas and cresting, allow the designer to enliven and delineate the structural silhouette and relate the public exterior environment to private indoor spaces. These features often work in combination with such landscape elements as fences, walkways, street and garden furniture and plantings. In urban areas, decorative architectural features repeated on adjacent properties can define the character of a streetscape.

Preservation of these features is a priority. If part of a decorative feature is missing, it is often possible to accurately reproduce it using surviving evidence or documentation. Otherwise, contemporary design solutions should be found to recapture some of the small-scale animation of the original. A traditional porch, for example, introduces a three-dimensional human scale into the landscape and uses a partially open, often decorative framing system to indicate the transition from public to private space. A contemporary reinterpretation should be developed from traditional design criteria such as these.

Interior finishes and decorative detailing are often radically altered in rehabilitation, usually much more so than is necessary. Reworking should be kept to a minimum and, in particular, the relationship between layout and decoration maintained. The pattern of public entry and distribution was often not only carefully designed but also lavishly decorated; it also provided the most important point of continuity between the exterior and interior.

If choices must be made, first priority should be given to preserving original finishes and architectural details in these areas. Such features could include baseboard trim, door and window architraves, wainscotting and panelling, cornice mouldings and other plasterwork and accessories such as period light fixtures, heat registers and other service equipment. Original lath and plaster wall surfaces are often fully reusable. Their slightly modulated finish coats are more sympathetic visually than the hard flatness of modern wallboard. Evidence of earlier colour schemes can be used as a starting point for any new painting or varnishing scheme.

Pressed Metal Ceiling

Second priority should be given to public assembly areas located off this distribution network (often highly decorative as well) and third priority to private spaces. Specific decisions on what can be reused will depend partly on the predesign analysis and evaluation of what survives. In all cases, an attempt should be made not only to preserve finishes in isolation but also to create an experience of the interior which has some sense of the original design concept for the site as a whole. For example, as a rule, interior window surrounds should be maintained throughout a project, since they provide local areas of continuity between interior and exterior.

New materials, finishes and trim should respect the proportions and interrelationships of colour and texture established by the original design. If done within this context, they can help integrate new patterns of use and space.

4.6 STRUCTURAL DESIGN AND DETAILING

The overall structural system of a building includes subsurface conditions, foundations and above-ground support systems. Every historic structure intended for reuse must be analysed to identify these components and to evaluate their condition and load-bearing capacity. Rehabilitation may involve significant upgrading of one or more aspects to cope with new functions and to meet applicable regulatory requirements.

As with the architectural aspects of the site, such activity must not only address the technical problems of reuse but also consider preserving or reinstating significant aspects of the original (or subsequent) structural designs. A building or engineering work may be of interest primarily as an engineering feat and preserving its structural behaviour may be more important than simply preserving its outward appearance.

Where the design and behaviour of the original structure are of prime interest, rehabilitation is constrained by finding new occupancies which imply similar or reduced loading conditions and structural code requirements. Stabilization measures should not obscure the original pattern of structural units and connections.

Where structural design is of secondary interest, various modifications can upgrade existing systems. Different kinds of performance criteria may have to be dealt with, including increases in load capacity, fire resistance and earthquake protection.

For increased load capacities, individual members and connections can be strengthened by internal consolidation and bracing of various kinds. Where such strengthening disrupts existing finishes, it may be better to introduce an entire secondary support system using new materials. Suspending upper floors from roof trusses (using vertical tie-rods) or from trusses covered over and serving as an interior wall, was often used in the past to provide large, column-free, open spaces on lower levels, a practice that can sometimes prove advantageous in rehabilitation.

For increased fire resistance, fire-rated separations may have to be introduced to protect exposed structural members or existing floor and wall separations may have to be upgraded. As discussed above, some of these disruptions can be reduced by careful attention to use and occupancy; others, by the employment of sprinkler systems in conjunction with a concentration of new, non-combustible materials providing structural support and isolation of the essential egress routes. Fire protection engineering solutions should evolve from the predesign inspection report and be carried out in ongoing consultation with local officials.

For increased earthquake resistance, improved tensile strength is likely to be required at the connections between vertical and horizontal components, particularly at perimeter walls. The bracing effect of adjacent properties should also be analysed and possibly restructured.

For most structural design modifications, various options will satisfy immediate technical requirements. Design options should be evaluated on how they affect the important architectural assets of the property identified in the predesign phase. Often, certain areas or aspects of a structure are more easily altered without seriously damaging an original desired effect.

4.7 ENVIRONMENTAL CONTROL SYSTEMS

Many period building services were components of an environmental control system directed toward the regulation of light, temperature, humidity and ventilation. Environmental control, whether in new construction or in rehabilitation, has two primary, interrelated aspects:

a. the passive protection against adverse conditions afforded by the structure itself; and
b. the active protection introduced by various mechanical and electrical systems.

Passive protection varies with the design of the perimeter envelope. In many cases, upgrading is required. Two alternatives are available:

a. To concentrate all insulation, energy absorption and weatherproofing in the exterior walls, openings and roof surfaces to provide a single, highly effective barrier between indoor and outdoor conditions. This is the normal practice in new construction, where triple-glazed openings, substantial quantities of insulation and continuous vapour barriers can allow air at +20°C, 50 percent r.h. and air at -20°C, 10 percent r.h. to co-exist within a few centimetres of each other.
b. To subdivide an existing structure into zones to allow a more layered, variable protection against outdoor conditions. This approach to environmental control was more common in the past, as much by necessity as by choice and may prove a sympathetic alternative in some rehabilitation design schemes.

The first alternative, which assumes full control and uniform distribution of interior temperature and humidity, requires an unbroken vapour barrier. In a few cases, if a satisfactory barrier

already exists, insulating materials can be blown into the wall cavities once the pattern of cavities has been established.

If an adequate vapour barrier does not exist, blown-in insulation will hasten deterioration of walls through high humidity levels and condensation. Proper installation of a vapour barrier means removal of either the interior or the exterior finish and sheathing on all perimeter walls, and sealing openings with multiple-glazed, fixed-sash or tight-closing window units. Destruction of historic fabric is almost inevitable in most cases, but if heating, ventilating and air-conditioning (HVAC) equipment is installed to modern climate control standards without a thorough reworking of the building envelope, serious internal deterioration is unavoidable.

With the second alternative – providing more graduated environmental controls – many surviving design features may be reusable. Exterior walls with valuable finishes can simply be sealed against obvious air and vapour penetration and air spaces blocked, where accessible, to ensure dead air pockets. Full insulation to contemporary standards is then provided only in accessible areas such as crawl spaces and attics or outside subsurface foundation walls.

Period doors and window sash can be repaired and preserved in place or replaced in kind, with removable double-glazed storm windows designed to fit snugly against the inside or outside frames during winter. Insulating curtain or drapery material can also be considered. Storm windows, if new and visible on the exterior, should have a sympathetic appearance, whatever their material and, in particular, a suitably deep profile to the rails and stiles.

This approach implies natural ventilation in summer, possibly supplemented with ceiling fans or other mechanical systems. Passive internal ventilation systems already exist in some 19th-century buildings and can be examined for possible reuse. Temperature and humidity levels will fluctuate in response to outside conditions but, in many instances such as masonry wall construction less dramatically than in new construction because of the building's considerably higher thermal mass.

In the winter, perimeter areas may be noticeably cooler even with heating systems designed to counteract this effect, in which case, patterns of use can be arranged correspondingly. Existing spaces with northern exposures or poorly insulated walls can be designated for storage, circulation or other buffer zone activity and places of sedentary activity located in central areas or along warmer exposures.

Active protection, as in the heating systems just discussed, should be designed only after the passive protection has been determined. Hermetically sealing a building (the first alternative), implies contemporary HVAC equipment. There is usually little chance of reusing existing systems, since the context will have been altered significantly. However, ductwork locations, chimneys and other elements can often be utilized in a new system.

Unobtrusive installation of new systems should be a design criteria from the start. It is advantageous to locate existing chases or flues, possibly blocked up and hidden from casual observation, which can be opened and reused. Installing hung ceilings to create a usable plenum is not advisable because of altered room proportions and obscured finishes and decorative detailing. If new flooring is to be installed, a floor plenum may prove satisfactory. Otherwise, ceiling services should be restricted to partial enclosures or exposed suspended units which do not hide the original expanse.

For a more gradual adjustment to modern standards (the second alternative), less obtrusive heating systems may be practical. Electrical systems are the most adaptable, but often inefficient in a retrofit. Steam or hot-water systems are next in terms of size requirements and may allow partial reuse of an existing layout. Zoning patterns and control systems usually require upgrading even if period fixtures are still serviceable. Hot-air systems are the bulkiest but, because they provide ventilation in addition to heat (and have the potential for air conditioning), they are the most flexible as control devices. Heating system design will vary considerably from site to site. With imagination, options such as solar retrofit or woodburning stoves may be feasible in some contexts.

Lighting systems can also be designed to contemporary standards using fluorescent units in patterns that achieve uniform illumination levels. However, more sympathetic design options are available. If fluorescent units are used, their appearance from outside the building at night should be a major aesthetic concern. Circular tubes and reflected lighting should be considered, as well as various fluorescent light tones (daylight versus cool white) that produce a warmer (more yellowish) colour, closer to incandescent hues or gas, candle and other flame sources of light.

Another approach is to vary illumination levels according to use and layout. Utilizing low intensity overhead fixtures and more localized, higher intensity light sources at individual work stations (or change points in the distribution system) can help maintain a feel of the past and promote energy conserva-

tion at the same time. It also may allow reuse of existing period fixtures, although the period wiring itself will have to be inspected and, in most cases, replaced. It may be appropriate, when renewing the wiring, to reuse or adapt existing conduits which might have had a decorative aspect, such as surface-mounted units of wood or metal.

Plumbing systems, like other services, should reuse existing chases and unused flues where possible. Unobtrusive installation is again the major concern. Activities requiring plumbing facilities, such as washrooms, kitchens, workshops and laboratories, should be located according to existing patterns where possible. This approach, apart from preserving the functional integrity of the building, is most likely to allow reuse of existing chases and fixtures and to provide the cost benefits of grouping these facilities in certain areas.

5.0 CONCLUSION

Each of the various aspects of rehabilitation design discussed above can be dealt with separately, but at some point these parts must be pulled together to create a whole. It is important that the various specialists involved be part of a project team which meets regularly to exchange information and ideas. The team itself must operate within the context of shared and quite well defined objectives in terms of both protection and enhancement of the historic resource.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

5.2
REHABILITATION
OCCUPANCY AND LAYOUT

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: BYRON JOHNSON

CONTENTS

1.0 INTRODUCTION

The purpose here is to give guidance for determining the decisions appropriate for the occupancy and layout of a rehabilitated or restored asset.

2.0 GUIDELINES: PREPARATORY TASKS

2.1 HISTORIC LAYOUT

Each historic structure has had a distinctive pattern of use which reflects the socio-economic situation of its evolutionary context. A thorough historical analysis will define the patterns of use and allow determination of the hierarchy of spaces as they existed at the various periods of interest. This hierarchy should be respected in any new layout or design scheme for the building as it will usually be very close to the eventual layout which best meets user requirements.

2.2 BUILDING CODES

Frequently, construction details such as the steepness of stairs, fire separations and size of rooms are designed to suit the historic layout. Whether or not the historic layout is to be maintained, the following attributes of the structure are important to note before rehabilitation planning:

a. fire combustibility of floors and interior partitions;
b. fire performance rating of floors and walls which might be used as fire separations in accordance with building code definitions;
c. location and design of plumbing and heating system elements;
d. location, steepness, width, shape and other characteristics of stairs relating to the requirements of the National Building Code; and
e. the floor area, height and number of exits from each major room.

An evaluation of these attributes is required to determine the adequacy of the existing building to meet the requirements of the new use. Several provinces have provisions for allowing tradeoffs between various fire safety measures; so that the effects of a change of occupancy can be reduced.

A thorough analysis of the requirements of the occupancy class is very important. Buildings which are to be used as museums or some other unusual occupancy do not fit well within the occupancy descriptions of the National Building Code. It is important to review the code requirements and determine which class of occupancy would lead to the fewest changes to the layout, fixtures and finishes.

3.0 PRINCIPLES FOR REHABILITATION

3.1 CONTINUED HISTORIC USE

The least disruptive rehabilitation may be one which perpetuates the historic use in whole or in part. If no change of occupancy occurs, then it is possible that certain, potentially disruptive, provisions of the building codes may not be mandatory. If the desired occupancy is similar to the historic, but with an intervening period of differing occupancy or vacancy, then the authority having jurisdiction may accept that there has been no fundamental change of occupancy. However, whenever the rehabilitation costs exceed some predefined limit (for example $50 000) then provisions of the applicable building code become mandatory for approval.

3.2 RETAINING RELATIONSHIP OF SPACES AND CONNECTIONS

The way that spaces and connections in a building relate to each other is worthwhile retaining in rehabilitation works. The public will appreciate a historic structure through preconceptions. Certain features of the building or work will be expected to be used in specific ways. Changes such as making the front entrance purely ornamental, can disorient visitors. If enough of the basic relationships are altered the historic structure will loose its integrity and meaning.

Many structures had a hierarchy of spaces (i.e. public rooms on the front ground floor, service rooms at the rear, private rooms above). If this hierarchy is upset the building may become unintelligible.

The retention of the original spatial hierarchy also helps to retain the functions of the spaces so that the services can generally be retained.

3.3 MODIFICATION OF OCCUPANCY OR LAYOUT

If the features specified for examination in the guidelines have been duly noted, then it should be quite simple to use these features for a modified layout.

Fire separations are often easier to achieve vertically than horizontally, thus additions to the building (or wings off the main building) can be separated to allow the main building to fit within the least stringent height and area categories.

Other minor features, such as blocked-up windows, although not generally acceptable, may be occasionally used to advantage in a new use such as display rooms where delicate artifacts must be kept out of direct light.

3.4 AVOIDING CHANGES TO HISTORIC FABRIC

It is necessary first to understand the building; its history, its features and its conditions. Then the rehabilitation or restoration can be undertaken, always bearing in mind that the fewest changes to the historic occupancy and layout will result in the least damage to historic fabric.

VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

5.3
REHABILITATION
STRUCTURAL MODIFICATIONS

PRODUCED BY:
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ORIGINAL DRAFT: P. STUMES

CONTENTS

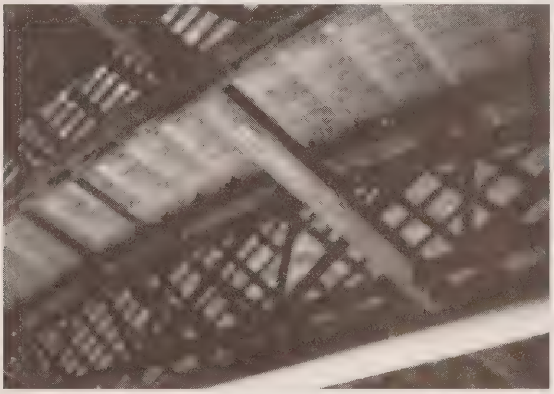
1.0 INTRODUCTION

Structural modifications represent changes and alterations made to the load bearing systems in historic buildings. The reasons for these changes may be one or more of the following:

a. due to deterioration the load bearing elements can no longer support the imposed stresses;
b. increased live loads or dead loads are imposing additional stresses on the original load bearing elements; and
c. realignment of spaces or increased spans require additional supports or strengthening of the existing support systems.

No matter what the purpose of the modifications, they usually involve changing the historic configuration of the building and or its structural system. While such interventions may not be desirable in many cases, for practical reasons they are unavoidable.

The purpose of this report is to provide guidance in selecting methods of structural modification, with full consideration for the principles of historic conservation.



Sistering of Original Lattice Truss Using New Hollow Structural Steel Trusses. Borden Hangars, CFB Borden, ON.

2.0 SCOPE OF STRUCTURAL MODIFICATIONS

2.1 INTERPRETATION OF TERMS

In order to avoid misunderstandings we are listing here the interpretation of some of the expressions used in this article.

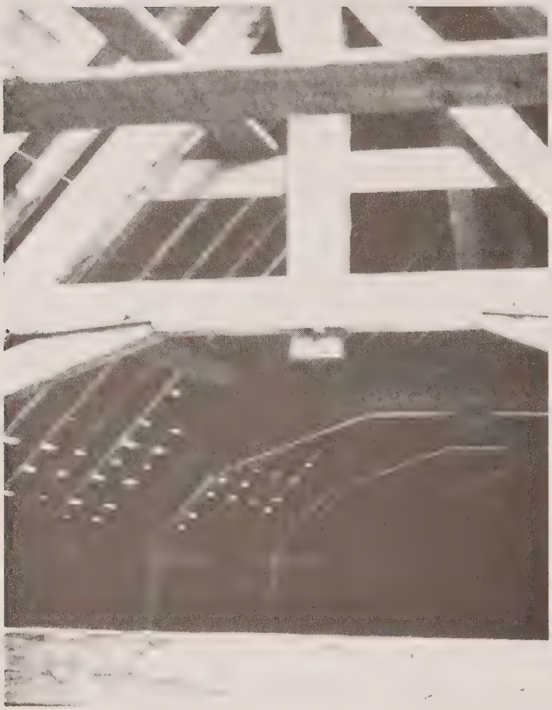
a. Building:
A human-made enclosure, erected for the purpose of providing a suitable environment for human activities For the purposes of this report only, to simplify the text, the word "building" will represent not only edifices and the like but also bridges, fortifications and other human-built historic objects.
b. Structure:
The structure is those parts of a building which are primarily responsible for carrying loads or resisting stresses. All building components must resist some stresses, such as windows resisting wind pressure and roof tiles carrying snow loads. However, these are only incidental to the main role of such components and therefore they will not be considered in this report.
c. Modification:
The modification represents removal or rearrangement of structural elements and also the installation of new structural elements. The replacement of deteriorated structural elements with a replica of the original does not constitute structural modification.

2.2 PURPOSE

Structural modifications may be justified either because of immediate necessity or because of future utility.

Structural modification of historic buildings may be an immediate necessity if the load bearing elements can no longer support the loads nor resist the stresses imposed and their repair or reconstruction in kind is not feasible.

Structural modification may become justifiable for reasons of utility if a building is to be adapted to new purposes that will cause stresses on the load bearing elements beyond their existing capacity.



Complex Period Truss System – mathematical modelling challenge for the engineer

2.3 LIMITS

Modification represents an intervention which is limited to those areas which do not change the original architectural integrity of the building.

Installing new columns, beams, buttresses, trusses and the like, to reinforce the existing architectural elements, (walls, floors, roofs, etc.) is considered to be modification. Constructing new walls, floors or whole building sections is not considered to be modification. These actions are within the concept of redevelopment.

2.4 RECORDING

All modifications to historic structures must be accurately documented in reports, drawings and photographs. Reports must include the storage location of removed parts. Newly installed parts must be marked as such in order to prevent their being mistakenly identified as original historic members.

3.0 PLANNING STAGE

3.1 STRUCTURAL ANALYSIS

Modification of structural systems may be necessary if the load bearing capacity of the structure has diminished or if the demand on the structure has increased.

In either case, prior to the implementation of a modification the condition of the structure must be thoroughly analysed. The analysis is executed in two stages:

a. analysis of the conditions and load bearing capacity of the existing structure; and
b. determining the magnitude, type and location of the expected loads.

The analysis should be conducted as specified in Vol. III. 5.2 Historic Site Analysis, "Structural Diagnosis."

The final result of this analysis will be locating the points where modification is necessary and defining the basic concepts of required modifications.

3.2 POLICY

If, based on the structural analysis, some structural modification is planned, the method of modification should be selected according to the general principles of historic conservation. It must be remembered that:

a. installation of exposed structural elements may change the architectural integrity of the building;
b. replacement or repair of existing structural elements may represent partial or complete destruction of historic fabric; and
c. most types of modifications may cause impairment of the historic appearance and deface original finishes.

Research must be carried out to find methods which will avoid visual and physical intrusion into the historic environment.

If no such methods are found, the installation of temporary structures must be considered. Such structures appear for a time unsightly. However, they may permit carrying of the loads, without permanently injuring the historic building. At a later date new discoveries may permit installations which cause minimal interference. At that time the temporary modifications can be removed and the historic building left undamaged.

3.3 LEVELS OF INTERVENTION

When modification is necessary and intervention is unavoidable, the method of modification must be selected by considering the following:

a. The relative significance of the original fabric or the architectural features must be balanced against each other. For example, to preserve the visual integrity of significant open spaces it might be preferable to replace original supporting beams or to install secondary beams. On the other hand, it might be preferable to install new columns if the supporting beams have highly valued artistic decoration.
b. There are many modern technologies available which can increase the load bearing capacity of existing structural elements. Some of these technologies may require the wasting of parts of the original fabric, without visibly affecting the reinforced element. Depending on the intrinsic values attached to the original fabric as a whole, the use of such techniques may or may not be permitted.
c. Whenever possible, structural modifications should be made in a manner that insures the reversibility of the process. It is possible that present requirements for modification may not exist in the future. In that case it may become advisable to return the building to its historic configuration by removing modifications.
d. Structural modifications may be carried out by using period techniques and materials. The use of historic techniques may cause the least interference with the visual integrity of the building because such structural elements may blend well into the original environment. However, this may be considered falsification and therefore any such replica of original elements must be permanently marked to ensure that they can be distinguished by experts.
e. To avoid falsification of historic appearance, in most cases, structural modification is carried out with the installation of modern structural elements. When appropriate materials, shapes and colours are selected such modern elements may blend into the surrounding historic environment, while remaining unmistakably modern additions for the observer.

Among the many, sometimes opposing alternatives, the minimal intervention and the least intrusive can be selected through consultation with all parties: historians, architects, engineers, managers, end-users and others.

4.0 DESIGN ALTERNATIVES

There are many design alternatives for structural modification. The following examples provide some indication of the variety of techniques available. In most conservation projects, these techniques must be customized to fit the particular situation at hand.

4.1 FOUNDATIONS

- underpinning
- buttressing
- transfer of loads – to new continuous foundations or individual piles or piers

4.2 WALLS

- external bracing, buttressing
- internal reinforcement (wood)
- stabilization (masonry, wood) – see Section 4

4.3 COLUMNS

- external bracing
- internal reinforcement
- transfer of loads

4.4 BEAMS

- external bracing/sistering
- internal reinforcement – see Section 4
- transfer of loads
- reduction of clear span (support from above, e.g. tie rods – support from below, e.g. new columns)

4.5 JOISTS/RAFTERS

- reinforcement/sistering
- full or partial transfer of load (new intermediate members, alternate support systems)
- reduction of clear span (intermediate beams – above, below or in same plane as joists/rafters)

4.6 TRUSSES

- reinforcement of individual members
- reinforcement/modification of joints
- new members
- transfer of loads

4.7 ARCHES

- bracing/cross ties
- transfer of loads
- reinforcement

Internal Reinforcement

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

5.4
REHABILITATION
FIRE PROTECTION

PRODUCED BY:
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CONTENTS

1.0 INTRODUCTION

As historic buildings seldom comply with modern code requirements, this publication outlines various fire protection procedures and systems that will be compatible with historic/aesthetic values without seriously limiting operational capability.

1.1 APPLICATION

This publication is intended for the guidance of headquarters and regional administrative and technical staff.

2.0 IDENTIFICATION OF HAZARDS

The word "hazard" is used in different senses:

a. to indicate materials of more than average combustibility or that are explosive, unstable or toxic;
b. to describe the over-all degree of fire vulnerability of a property, in terms of its fire load. For example, sprinklers require closer spacing in a special-hazard occupancy than in a common-hazard occupancy; and
c. to describe the nature of the fire problem. For example, "common hazards" are ignition sources encountered in almost every class of property (smoking, heating, electrical, etc.). "Special hazards" are those considered peculiar to an individual property (candle making, dip tanks, spray booths, etc.). There is no firm line of demarcation between common and special hazards, as the same potential fire cause may be considered a common hazard in one occupancy and a special hazard in another.

2.1 SITE ANALYSIS

A complete data gathering process must be undertaken before decisions can be made regarding the degree of fire protection required on any historic site or how to minimize the fire danger to life, buildings and contents. This data gathering is accomplished by performing a comprehensive inspection tour of the premises.

2.1.1 Site Inspection Report

A permanent, precise and complete narrative report, describing the fire protection features and fire hazards of the property, is essential and should encompass the following general items:

- property identification
- occupancy
- construction type
- life safety features
- common hazards
- water supply
- extinguishing systems and devices
- alarm and detection systems
- fire prevention features
- recommendations

2.1.2 Site Layout (Plans)

A site analysis requires a plan indicating the physical characteristics and layout of the premises. On-site sketches by the inspector assist in the preparation of the finished plan. Water supplies, power sources and exposures from adjoining property are a few of the features required on the sketches.

2.2 BUILDING/STRUCTURE ANALYSIS

Buildings/structures must undergo an inspection tour of a calibre similar to the site analysis. With a greater variety of possible hazardous situations, however, the data gathering process will be more involved.

2.2.1 Building/Structure Inspection Report

The Building/Structure Inspection Report shall be a permanent, precise and complete narrative report describing the fire protection features and fire hazards of the property. The areas of concern identified in 2.1.1 also apply to this report.

2.2.2 Building/Structure Layout (Plans)

It is most important to procure a room-by-room, floor-by-floor set of building plans to facilitate the preparation and finalization of the building analysis. The use of original and existing plans in combination with the inspection tour and its reports, would aid the inspecting party in the development of an updated, comprehensive building plan indicating all pertinent data required to produce meaningful recommendations.

2.3 RECOMMENDATIONS

The final evaluation of the analysis frequently indicates that the site or building does not meet the overall requirements of life safety, fire protection and construction codes, including the standards specified in the National Building Code of Canada (NBC), National Electrical Code of Canada (NEC) and by the Fire Commissioner of Canada (FCC). Only experienced and competent fire protection engineering officials should make the thorough evaluation and the necessary recommendations for appropriate fire protection. Architects, engineers and designers may have a limited knowledge of codes and standards in this field but seldom to the same degree or level of interpretation as fire protection engineering officials.

In addition to the advisory service available in headquarters, advice, inspections, testing and acceptance services are available from the FCC or from the Regional Fire Commissioners (RFC). All analyses and proposals are to be submitted to the FCC or regional representative for approval.

Additional information relating to fire inspection methods and areas of concern is available in the *National Fire Protection Association (NFPA) Handbook,* 14th Edition, Section 18 and the *NFPA Inspection Manual.*

3.0 DESIGN ALTERNATIVES

As the majority of historic buildings and structures were constructed in an era lacking present-day knowledge and technologies, there will be many factors to consider when confronted with the problem of non-conformance to existing life safety, fire and building codes.

It is not our desire to relax these time-proven codes to accommodate historic structures. They can be met or even exceeded in some cases through careful application of the various codes and the use of appropriate trade-offs or compliance alternatives. In this way, the safety and integrity of the building or structure can be maintained.

The life safety of any individual (employee or the public) is the prime concern in historic buildings. The second concern is the building and/or contents, depending upon the historic and monetary values.

Before any decision is made regarding fire protection or life safety requirements, the overall individual situation must be analysed. Is the building or structure going to be opened to the public? If so, to what extent? An initial study may indicate that it may not be feasible to open it to the general public. A further study utilizing technical knowledge and trade-offs with various codes could result in a fire-safe situation with less cost and interference to the original fabric or integrity of the structure.

The information contained in the following paragraphs will give insight into some factors that must be considered when confronted with the difficult task of contemplating and carrying out design alternatives for historic buildings and structures.

3.1 OCCUPANCY LOAD CONTROL

a. Occupancy means the use or intended use of a building or part thereof for the shelter of persons, animals or property.

b. Assembly Occupancy means the occupancy or use of a building or part thereof by a gathering of persons for civic, political, travel, religious, social, educational, recreational or similar purposes or for the consumption of food and drink (historic buildings and structures are often classed within this occupancy). See NBC 3.1.2. and Tables 3.1.2A, 3.1.3A, Group A Division 2.

   Note: Every room constituting a place of assembly shall have the occupant load of the room posted near the main exit if the load is greater than 60 people (National Fire Code of Canada, (NFC) 27.1.6).

c. Occupant Load means the number of persons for which a building or part thereof is designed. Unless otherwise approved, this shall not be more than the number of persons that can be accommodated on the net floor area or part thereof in accordance with NBC, Part 3, Section 3.1.1.6 and Table 3.1.1.6A. The occupant load is one of the factors which determines the number, location and size of exits required to serve a floor area or vice versa.

d. Major Occupancy means the principal occupancy for which the building or part thereof is used or intended to be used and shall be deemed to include the subsidiary occupancies which are an integral part of the principal occupancy.

3.1.1 General

Where alterations are made or changes of Major Occupancy occur in an existing building, (which normally happens when a historic building is opened to the public), the requirements of the NBC shall apply. For example:

a. If a historic building is opened to the viewing public, the Major Occupancy would, in many cases, change from Residential Occupancy to Assembly Occupancy. This would change the fire safety requirements. Initially this would seem restrictive, but from a practical viewpoint, it may not be.

b. The Assembly Occupancy is the area that the viewing public would occupy. This area would have to comply with the applicable life safety requirements of the NBC, NFC codes and the FCC and Treasury Board (TB) standards. The protection requirements for the remainder of the building may be left to the discretion of the Administrative Official and would not necessarily be equivalent to the NBC provided that adequate measures are taken for the safety of employees as required by Part IV of the Canada Labour Code.

c. Occupancy Requirements for a designated heritage building which is to be opened to the general public and also serve as a functional building, e.g. light industrial, mercantile, offices, restaurant, etc., are contained in the NBC, Section 3.1.3, "Multiple Occupancy Requirements."

Each building and room must be evaluated separately. The information obtained from the site-building analysis will assist in determining the extent to which the building may be used and will assist in the development of a cost analysis.

3.2 MEANS OF EGRESS

As exiting from a building is paramount in life safety requirements, the subject must be considered in depth.

"Means of Egress," according to the NBC, means a continuous path of travel provided by a doorway, hallway, corridor, exterior passageway, balcony, lobby, stair, ramp or other egress facility or combination thereof for the escape of persons from any point in a building, floor area, room or contained open space to a public thoroughfare or other approved open space and includes exits and access to exits.

Broad Exit Stairs

3.2.1 General Requirements: Exits

"Exit" as defined by the NBC means that part of a "means of egress" that leads from the floor area it serves, including any doorway leading directly from a floor area, to a public thoroughfare or to an approved open space. The general requirements for exits are detailed in section 3.4 of the NBC.

Adequate exits shall be provided from all parts of the building that the visiting public occupies. The minimum number and location of required exits is detailed in the NBC section 3.4.2. For example:

If the occupant load (group a) is not more than 60 persons in a building of two storeys or less, it may be served by one exit, provided the floor area does not exceed 150 m^2 (1500 ft^2) and the minimum travel distance is 15 m^2 (50 ft^2).

a. Width and Height

Exit widths, width based on occupant load, exits from interconnected floor spaces, capacity per unit of exit width, reduction of exit width and headroom clearance are detailed in the NBC Section 3.4.3.

b. Flame Spread Rating

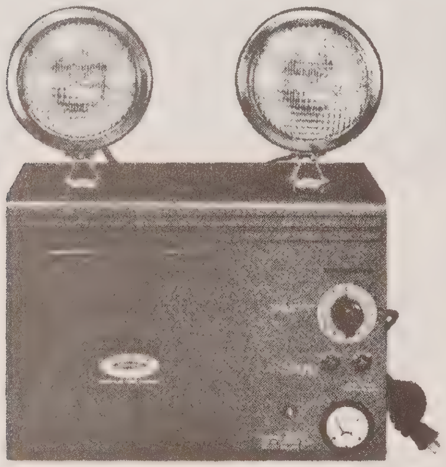
Refer to the NBC, Section 3.1.11.

c. Required Fire Separation

Refer to the NBC, Section 3.4.4.

d. Signs

Refer to the NBC, Section 3.4.5.



Emergency Lighting

3.3 EMERGENCY LIGHTING

Emergency lighting equipment is a modern innovation which is not a part of traditional decor. The equipment, if necessary, must be installed in an unobtrusive manner and still be functional.

a. References

The NBC, subsection 3.2.7 describes the requirements for emergency lighting; and the NFC, subsection 2.7.3 and article 1.1.4.2 discuss the deviation regulations.

b. Certification

All emergency lighting units must conform to CSA C22.2 No. 141 "Unit Equipment for Emergency Lighting."

3.4 BUILDING EVACUATION

The provision of exits does not ensure the safety of building occupants. Proper evacuation methods and procedures should be planned organized and practised.

3.4.1 Procedures

a. All staff should be advised of the evacuation signal and they should be familiar with the closest exit route and alternate routes. Staff should be trained and assigned to control the pedestrian traffic and to isolate the emergency area.

b. They should also be instructed to shut off all equipment immediately upon hearing the signal and to close doors behind them as they exit.

c. An important question is "when to evacuate." In case of doubt, the building should always be evacuated. Necessary functions of the staff include checking exits, selecting evacuation routes, searching for stragglers and controlling re-entry when this is safe.

3.4.2 References

For emergency planning for building evacuation, refer to the NFC, Section 2.8.

4.0 STRUCTURAL FIRE PROTECTION

Six major categories of physical intervention can be identified in the treatment of historic sites and structures. (See IV.1 "Levels of Intervention.")

a. Interim protection:
   the temporary consolidation and mothballing of historic resources while they await long-term preservation or adaptation.
b. Stabilization:
   the full preservation and consolidation of the existing form, integrity and material of historic resources.
c. Contemporary rehabilitation:
   the adaptive modification of historic resources to contemporary functional standards while preserving their historic form, material and integrity as much as possible.
d. Period restoration:
   the recovery of the historic form and detailing of historic resources by removing later additions and replacing the missing elements as accurately as possible.
e. New development:
   the replacement or infill of historic resources with new structures and facilities sympathetic to the historic environment but designed to contemporary functional standards.
f. Period reconstruction:
   the accurate reproduction of nonexistent or poorly preserved historic structures and resources.

Each category has different implications for structural fire protection design. In an interim protection phase, a site is often closed to the public. This reduces the requirements for life safety but the need remains for temporary systems to protect the real property.

In the case of stabilization, rehabilitation and restoration, both life safety and the protection of real property must be considered. The required installations and modifications must be designed to cause as little damage as possible to surviving historic fabric and the completed systems should intrude as little as possible on the historic atmosphere.

In the case of redevelopment and reconstruction, installation and structural modifications are simplified because they can be incorporated into the design and construction process. Design sensitivity is still required, however, especially in period reconstruction, to ensure that the completed systems respect the historic environment.

4.1 MAJOR OCCUPANCY CLASSIFICATION	NBC (National Building Code of Canada)
The intended use of a building influences the degree of structural fire resistance required. Structural elements and building contents, should be capable of withstanding a fire until firefighters can gain control of the fire. This depends largely on the quantity and inflammability of combustible material associated with the intended use of the building.	Major occupancy classification Table 3.1.2A. Other occupancies exceeding 10 percent of the floor area on which they are located: Sentence 3.1.3.1(6)
In general, requirements are more demanding for larger buildings than for smaller buildings. The structural stability of a building in a fire becomes increasingly important the greater the building height. There is increased damage potential from collapse and more time is necessary to safely evacuate occupants.	Building height: Subsection 3.2.2 Building area: Subsection 3.2.2
If the external building face is directly accessible to fire fighters, action can be initiated faster and more effectively, thus limiting fire growth.	Number of street facings: Article 3.2.2.6

4.2 MINIMUM CONSTRUCTION REQUIREMENTS

A properly designed sprinkler system will control or extinguish a fire in a building. Therefore, increased building areas are permitted for the same construction types if the building has sprinklers.

The code classifies buildings into two major construction types: combustible and non-combustible. The distinction is that in the former the structural elements will contribute to a fire situation. In the latter, the code strictly limits the amount of combustible material to that permitted for insulation and trim work. (Requirements for construction types are in the code's Subsection 3.1.4).

The required fire resistance rating for the structural elements indicated in this section are determined from the tables in Subsection 3.2.2 of the code, on the basis of the height, area and occupancy of the structure. The ratings given for these elements are based on the required degree of fire resistance in hours for the various elements of the structure.

NBC

Subsection 3.2.2

Applicable section:
Sprinkler Protection

Maximum Height.

Maximum areas.
Construction type.
Floor assemblies
(fire resistance ratings required).

Above basement or crawl space (fire resistance ratings required).

Mezzanines
(fire resistance ratings required).

Roof assemblies
(fire resistance ratings required). Columns and load-bearing walls (fire resistance ratings required). Special requirements for high buildings:
Subsection 3.2.6
Special requirements for firefighting:
Subsection 3.2.5
Special requirements for atriums:
Subsection 3.2.8

4.3 OCCUPANCY SEPARATIONS

Because different fire hazards exist in different occupancies, the code requires a fire separation between these occupancies. The fire resistance rating of this separation depends on the combustible loading associated with the adjacent occupancies. (See Code Table 3.1.3.A.).

NBC

Occupancy Separations:
Subsection 3.1.3

4.4 OTHER FIRE SEPARATIONS

Protection of corridors is required in order to provide a degree of safety to persons moving to building exits in an emergency situation. Exit enclosures must be fire rated separations, not only to provide protection to persons using them to leave the building, but also to prevent the spread of fire and smoke from floor to floor. Service rooms and service spaces are likewise required to be fire separated from other areas because of the greater potential of fire occurring and remaining unnoticed in such areas.

Corridors – wall rating:
Sentence 3.3.1.3. (3)

Door rating:
Sentence 3.1.6.7 (1)
Exit enclosure:
Subsection 3.1.6.4

Other shafts:
Subsection 3.5.3

Service rooms:
Section 3.5.2.

Horizontal service space:
Subsection 3.5.4

4.5 PROTECTION OF OPENINGS

Any openings in fire separations must be protected to maintain the integrity of this separation.

Required fire protection rating of closures:
Article 3.1.6.4

Fire dampers as closures:
Article 3.1.6.5

Escalators:
Sentence 3.2.8.1 (7)

4.6 SPATIAL SEPARATIONS

These are designed to limit the spread of fire to adjacent properties. They are based on the size of the radiating fire compartment. NBC Tables 3.2.3 A. and 3.2.3 B. indicate the percentage of area of unprotected openings permitted in the exterior face of the building. These percentages are based on limiting distance, the area of the exposing fire compartment and the configuration of that compartment.

NBC

N S E W

Limiting distance.

Area of exposed building face.

Percentage of area of unprotected opening allowed.

Required rating of exposed walls.

Special conditions.

4.7 HAZARD OF CONTENTS

Hazard of contents is the relative danger of the start and spread of fire, smoke or gases generated, explosion or any other occurrence which may endanger the lives or safety of the building or structure occupants.

4.8 FIRE SEVERITY

Fire severity is determined by the material burned and its rate of combustion. Arrangement of the material has an effect on the speed of combustion. The quantity of material must also be considered when determining the duration of a fire.

4.9 FIRE LOAD

Fire load is the expected maximum of combustible material in a given area. It consists of the structural elements and the combustible contents within the area.

It is usually expressed as weight of combustible material per square foot of the fire area. The heat combustion is the amount of heat released during a substance's complete oxidation (combustion) and is referred to as calorific value and expressed in Btu/lb. One Btu is the amount of heat required to raise the temperature of one lb. of water one degree Fahrenheit. (See NBC Section 3.1, "Use and Occupancy").

5.0 FIRE DETECTION AND ALARM SYSTEMS

The field of fire detection, alarm signalling and controlling devices has become very sophisticated. There are systems that will do anything from detecting the most minute rise in temperature to initiating total flooding and fire extinguishing.

To determine what systems are needed and what components are best for a specific job, fire engineering specialists may be hired and/or representatives from reputable fire alarm system suppliers may be consulted. The proposed system's plans must be approved by the FCC.

A fire alarm system is a system whose primary function is to initiate and transmit an alarm signal manually or automatically, in the event of fire or other emergency.

A fire detector is a device which automatically senses a fire condition and automatically activates the fire alarm system. Types of detectors include:

a. ionization detectors which respond to the first traces of visible smoke or invisible products of combustion;
b. photo-electric smoke detectors which respond directly to visible smoke concentrations;
c. flame detectors which react directly to flame, sensing the infra-red radiation emanating from fire;
d. thermal detectors which are of the combination rate compensation/fix temperature type; and
e. ultraviolet detectors which react to extremely high frequency light rays emitted from fires.

5.1 MANUAL SYSTEMS

A manual fire alarm station is a manually operated device which activates a fire alarm system.

The installation requirements for Fire Alarm Stations are detailed in the Treasury Board Manual (TBM), Personnel Management – Occupational Safety and Health, Chapter 3-4, "Standard for Fire Alarm Systems."

5.2 AUTOMATIC SYSTEMS

An automatic fire *detection* system is intended to automatically detect a fire condition and transmit an alarm signal.

An automatic fire *protection* system is intended to automatically detect a fire condition, transmit an alarm signal and activate a fire extinguishing system. For further information regarding systems, see 6.0.

5.3 MUNICIPAL SYSTEMS

Municipal Systems are designed to transmit an alarm to the municipal fire department, see 6.7.

5.4 REFERENCES

Treasury Board Manual (TBM). Personal Management (PM) – Standard No. 5 – Occupational Safety and Health Chapter 3-2, "Fire Protection Standard for Design and Construction";

TBM PM – Occupational Safety and Health, Chapter 3-4;

National Building Code of Canada (NBC);

National Fire Code of Canada (NFC);

Canadian Electrical Code. Part 1 (CSA C22.1-1990);

Pyr-A-LarmLife Safety Systems, "Application Engineering Fundamentals."

6.0 FIRE SUPPRESSION SYSTEMS

All government of Canada buildings are equipped with some type of firefighting or fire control device from simple, manually operated devices to sophisticated automatic equipment. The simple hand-held fire extinguishers are available in different sizes, shapes and colours and contain different extinguishing agents, each for a specific purpose.

The more complex devices include:

- standpipe and hose systems
- sprinkler systems
- automatic halon systems
- various other systems

6.1 DEFINITION

Fire protection generally refers to those measures necessary to safeguard life, preserve property and reduce fire losses. Specifically, it includes the methods used to provide fire control or fire suppression, e.g. the use of portable fire extinguishers.

6.2 FIRE EXTINGUISHERS (HAND OPERATED)

6.2.1 General Requirements

Fire extinguishers shall be provided, appropriately located, adequately supported, protected and maintained in accordance with NFC, Section 6.2 "Fire Extinguishers."

6.2.2 Special Requirements

To prevent unnecessary damage that may be caused by the extinguishing agent, care must be exercised when selecting the type of extinguisher to be installed for use on or near irreplaceable historic artifacts.

6.2.3 Conditions

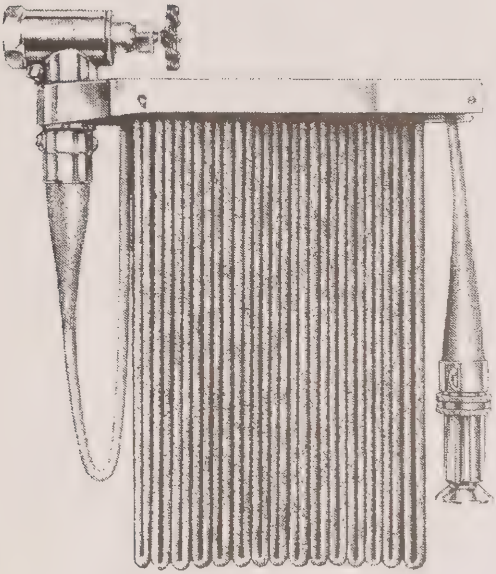
To avoid interference with the historic appearance of the environment and notwithstanding the requirements of 6.2.1, wherever possible, fire extinguishers should be installed in an unobtrusive manner. Where extinguishers are obscured, some means must be devised to ensure their availability in the event of fire.

6.2.4 Training

All staff must be familiar with the location of each extinguisher within the building in which they are employed. These locations may be indicated on a floor plan displayed in an appropriate place. Training programs should include operating techniques and the application of the extinguishers under realistic conditions.

6.3 STANDPIPE AND HOSE SYSTEMS

Standpipe and hose systems refers to piping arranged to supply water to hose outlets at designated locations throughout a building and to which a hose is either attached or may be attached for use in the event of fire.



Standpipe and Hose System

6.3.1 General Requirements

The requirement for a standpipe system installation is normally identified in the buildings's or structure's preliminary design stages, minimizing the problem of concealment. If a standpipe system is identified for an existing building or structure, due to the lack of access from the outside for the fire department, the concealment problem is more difficult to overcome.

6.3.2 Alternatives

Considering the problems that may be encountered, alternative methods of fire control would have to be considered in lieu of a standpipe system. One method would be to install a sprinkler system or extend the coverage of the existing one.

6.4 SPRINKLER SYSTEMS

Automatic sprinkler systems are one of the most effective and efficient means of controlling fires in buildings. Over a century of use, they have a proven record of performance and reliability in protecting both life and property. Consequently the NBC and NFC allow numerous "trade offs" in buildings with sprinklers, and the installation of a sprinkler system is frequently recognized by authorities as an acceptable alternative to complying with other prescriptive requirements of the codes. Concerns about excessive water damage are generally based on misconceptions about the operation and reliability of sprinkler systems. Accidental discharge is very rare and a properly installed system will generate less water damage than the later application of those streams by the fire service. The fire loss record is replete with heritage structures without sprinklers that have been completely destroyed by fire; but there are none that have been destroyed or even seriously damaged by the activation of a sprinkler. There are four basic types of sprinkler systems in use today. In descending order of reliability and ascending order of cost, they are:

- wet pipe
- dry pipe
- pre-action
- deluge

In addition there are numerous sprinkler heads designed to operate under certain temperatures or conditions. There are types which are self-stopping and self-starting. The application methods for specific conditions are numerous.

6.4.1 General requirements

In the preservation of historic structures, every attempt shall be made to comply with the NBC, NFC, FCC and TB Standards; however, compliance shall not be allowed to destroy or impair the integrity of a structure or its contents. Where it is impossible to meet the requirements of the codes and standards without altering the original fabric or integrity of the structure, operating procedures for the management of the structure shall be modified to alleviate the potential hazards to life and property. For example, artifacts may have to be displayed in a safer location, an automatic protective curtain or enclosure may have to be provided or an alternate fire suppression system compatible with the artifact may be installed. In any case, where deviation from FCC or TB Standards is contemplated, specific approval in writing shall first be obtained from the Fire Commissioner of Canada.

6.5 HALON SYSTEMS

Halon 1301 is a colourless, odourless, electrically non-conductive gas with the chemical formula $CBr\ F_3$ (bromotrifluoromethane) and according to the NFPA standard it extinguishes fires by inhibiting the chemical reaction of fuel and oxygen. The extinguishing effect due to cooling or dilution of oxygen or fuel vapour concentration, is secondary.

6.5.1 General

Several different halogenated fire extinguishing systems have been in existence for some time. Each of them evolved with advancing technologies. Halon 1301 is one of the latest halogenated agents accepted for fire extinguishing systems. Like all fire extinguishing agents however, it has certain limitations and applications. For these refer to the NFPA Standard No. 12A.

6.5.2 Types of Halon Systems

There are two approved types of Halon Systems:

a. Total Flooding System, which consists of a supply of Halon 1301 arranged to discharge into and fill to the proper concentration, an enclosure around the hazard; and
b. Local Applications System, which consists of a supply of Halon 1301 arranged to discharge directly on the burning material.

6.5.3 Conditions

There are many unique situations in the National Historic Sites system which require special attention to life safety and the protection of irreplaceable objects against fire or the extinguishing agent. Sound judgement must be exercised when installing fire suppression systems. In certain instances, a Halon 1301 system may be the only method that can be used. The cost of installation and maintenance warrants the weighing of monetary values against historic values. If this type of system is installed, like all modifications to existing historic buildings or structures, interference with the historic appearance must be minimal.

6.6 OTHER FIRE SUPPRESSION SYSTEMS

There are other fire suppression systems that use dry chemical, carbon dioxide, foam or other chemicals as extinguishing agents. Like the Halon 1301 system, they are designed to control localized fires such as in flammable fires in cooking range hoods, flammable-liquid storage rooms, paint spray booths, etc. All automatic systems should be supplemented with suitable hand-operated extinguishers. Some systems can automatically shut off the fuel and energy when fire is detected (see 5.0). Any system provided shall conform to TBM, PM – Occupational Safety and Health, Chapter 3-2, "Fire Protection Standard for Design and Construction."

6.6.1 Definitions

Dry Chemical is a powder composed of very small particles usually of sodium bicarbonate ($NaHCO_3$), potassium bicarbonate ($KHCO_3$) or monammonium phosphate ($NH_4h_2PO_4$), with added particulate material supplemented by special treatment to provide resistance to packing, resistance to moisture absorption (caking) and the proper flow capabilities.

Dry Chemical Fire Extinguishing Systems discharge dry chemical from fixed nozzles and piping or from hose lines by means of expellant gas. The use and limitations of these systems are discussed at length in NFPA Standard No. 17.

Carbon Dioxide (CO_2) is a colourless, odourless, electrically non-conductive inert gas that is a suitable medium for extinguishing fires. Carbon dioxide extinguishes fire by reducing the concentration of oxygen and/or gaseous fuel in the air to the point where combustion stops. The use and limitations of carbon dioxide systems may be found in NFPA Standard No. 12.

Foam as a firefighting agent is a stable aggregation of small bubbles of lower density than oil and water. It shows tenacious qualities for covering and clinging to vertical or horizontal surfaces. It flows freely over a burning liquid surface and forms a tough, air-excluding continuous blanket to seal volatile combustible vapours from the air. It resists disruption from wind and draft or heat and flame attack and is capable of resealing in case of mechanical rupture. Firefighting foams retain these properties for relatively long periods of time. Further descriptions of special types of foams and their applications can be found in NFPA Standard No. 11.

6.6.2 Personnel Safety

In locations installed with total flood systems, where there is a possibility that personnel may be exposed to a dry chemical or carbon dioxide discharge, suitable safeguards shall be provided and measures taken to ensure prompt evacuation and to provide prompt rescue of trapped personnel. Safety considerations such as personnel training, warning signs, discharge alarms, pre-discharge alarms and respiratory protection should be considered.

6.6.3 Material Object Safety

Before dry chemical or foam extinguishing equipment is considered for use in the protection of historic and/or delicate objects, the effect of residual deposits of dry chemical and foam on the specific item shall be evaluated. Dry chemical, when discharged, will drift from the immediate discharge area and settle on surrounding surfaces and into openings. Prompt cleanup will minimize damage.

6.7 MUNICIPAL OR LOCAL FIRE BRIGADES

Ideally an on-site professional fire brigade would provide the best possible fire prevention and fire fighting services. Most Canadian Parks Service (CPS) sites do not have an on-site fire brigade. Therefore, local voluntary or municipal fire brigades may have to be approached to provide this service. In some cases this would not constitute a problem as many of the historic or heritage structures are located within the local fire brigade's territory and may be considered part of the community. Where the historic structure or property is out of the local fire brigade's territory, fire protection of this nature may not be readily available. In either case, CPS should attempt to enter into negotiations with the local governments to obtain an agreeable arrangement, in writing, for the provision of these services.

Dawson Fire Brigade, Dawson, YT
National Archives of Canada, PA 13461. Larss & Duclos Photography

7.0 FIRE PREVENTION

7.1 DEFINITIONS

Fire prevention includes all the measures that can be taken to prevent the outbreak of fire, including fire protection. In the case of existing historic buildings and structures, a fire prevention program would include regular inspections of buildings or structures and surrounding areas for fire hazards, hazardous conditions or practices and their elimination through immediate corrective action. It would also include an ongoing fire safety awareness training program for all staff.

Fire protection includes all the measures that can be taken to control or extinguish any outbreak of fire in existing buildings or structures by applying relevant fire codes, e.g. installing fire suppression systems, extinguishers, detection and warning systems. In the case of the reconstruction of buildings or structures, protection and detection devices and materials can be designed into the building in accordance with applicable fire and building codes.

7.2 FIRE INSPECTIONS

There are basically three types of fire inspections:

- those that are carried out informally, day to day, by every individual in the workplace;
- those which are considered formal, usually conducted on a regular basis, e.g. weekly or monthly, preferably by a group which includes maintenance and administrative staff. It is easier to define, discuss and agree on the best methods of correcting hazardous conditions when several viewpoints are available; and
- those carried out by fire specialists where their expertise is required regarding fire protection and detection systems, safety features, layout of the building, interruption of water supplies, etc. (see 2.0). If there is any doubt or if specialized help is required, the regional advisor should be contacted. Aid can also be requested from the Fire Commissioner's office (Labour Canada) and from provincial or municipal authorities.

7.3 HOUSEKEEPING

The maintenance of clean and neat surroundings is basic to fire safety. It is a time-proven method of controlling the presence of unwanted fuels, obstructions and sources of ignition.

In large historic park complexes housekeeping is usually assigned to the maintenance staff as part of a daily routine. In smaller properties, such as the majority of CPS holdings, good housekeeping is an individual responsibility. All CPS staffers must be made aware of their responsibility to keep their work areas safe from fire.

Some basic aspects of housekeeping are:

a. operational tidiness and order;
b. proper control of waste; and
c. regulation of personal practices (e.g. smoking).

7.4 TRAINING

CPS shall ensure that all departmental personnel, including administrative, interpretive and maintenance employees, receive instruction in: proper fire prevention activities, the correct methods of responding to fire emergencies, the correct application of fire extinguishers, the protection and evacuation of park visitors and the protection and/or rescue of historically important artifacts.

Fire prevention and firefighting training requests shall be directed to the office of the Fire Commissioner of Canada. Additional specialized training may be obtained through negotiations with local municipal fire brigades or representatives of fire equipment manufacturers.

8.0 REFERENCES

GENERAL

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FIRE EXTINGUISHERS

National Fire Code (NFC), Section 6.2.

STANDPIPE AND HOSE SYSTEMS

National Fire Code, Section 6.4;

National Fire Protection Association Standard No. 14 "Installation of Standpipe and Hose Systems."

SPRINKLER SYSTEMS

Fire Commissioner, No. 403;

NFC Section 6.5;

National Fire Protection Association Standard No. 13 "Installation of Sprinkler Systems";

National Fire Protection Association No. TXT-1 "Automatic Sprinkler and Standpipe Systems."

HALON SYSTEMS

National Fire Protection Association Standard No. 12A;

National Fire Protection Association, No. SPP-26 "Fire Protection by Halons."

OTHER FIRE SUPPRESSION SYSTEMS

National Fire Protection Association Standard No. 17 "Dry Chemical";

National Fire Protection Association Standard No. 12, "CO_2";

National Fire Protection Association Standard No. 11 "Low Expansion Foam Systems."

MUNICIPAL AND/OR LOCAL FIRE BRIGADES

TBM, PM – Occupational Safety and Health – Chapter 3-1, "Standard for Fire Safety Planning and Fire Emergency Organization."

VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

5.5
REHABILITATION
MUSEUM ENVIRONMENTS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

This article briefly describes the technical specifications necessary to create a proper museum environment to safeguard artifacts in rehabilitated historic structures.

There are many factors to be taken into account: museum artifacts are threatened and easily damaged by prolonged vibration, variable atmospheric conditions, dampness, dust, air pollution, insects, moulds, fungi and common wear and tear. To create and maintain a proper environment is therefore very complex and few rehabilitated historic structures are suited for this purpose.

Modern technology brings not only many benefits but also many side effects detrimental to the environment. These and normal environmental changes will sooner or later affect historic structures and their artifacts. In spite of the inherent difficulties, a genuine effort must be made to carefully reconstruct and preserve all historically important structures and to create and maintain a museum environment for their artifacts if the heritage of human civilization is to be passed to the next generation.

2.0 MUSEUMS IN HISTORIC BUILDINGS

In most cases, rehabilitated historic buildings are assigned a new role or program. Rehabilitated historic buildings converted to museum use generally fall into three categories:

a. structures of significant historic value, usually connected with some event or person;
b. structures chosen to house a special exhibit; or
c. examples of folk architecture or vernacular groupings.

These groupings of significant architectural value, when integrated with the site, become not only a museum but also a housing display (for example, Upper Canada Village).

3.0 MUSEUM ENVIRONMENT COMPONENTS

3.1 SPECIAL INFLUENCES

There are three influences to be considered:

a. people – visitors and museum staff have direct and indirect effects;
b. interior design and overall architectural style – as a whole these affect internal usage; and
c. climate – the outdoor and indoor climates affect not only the building but also the artifacts on display.

Many old museum buildings, unlike most modern ones, have little control over their internal environments. Also, museum officials may create conditions which are more suitable for their visitors than for their collections (for example, the modern central heating plant, which is potentially hazardous to museum collections).

3.2 SPECIAL REQUIREMENTS

A museum is an artificial container within which artifacts must exist in a microclimate of controlled humidity, temperature, ultraviolet radiation and so on, while withstanding the dirt and disturbance of human activities. Some of these special requirements are discussed below.

3.2.1 Humidity

The optimal relative humidity (RH) of the air in museums, both in exhibition and storage rooms, is usually between 47 percent to 53 percent. During the day, the humidity should not deviate from these percentages by more than two percent. Metal artifacts or those of metallic content are sometimes placed in "dry" exhibition rooms, where the relative humidity can be safely maintained at 15 percent to 30 percent.

A high relative humidity may create undesirable indoor vapour pressures, especially in winter. This creates the need for effective vapour barriers, to avoid the problems of serious condensation in wall and ceiling cavities.

3.2.2 Temperature

The optimal indoor temperature for museum exhibits is 21°C. During the day, the temperature should not deviate from 21°C by more than 1.5°C. In any one month of the year, the temperature should not deviate by more than 3°C. Such temperatures are also easily acceptable to visitors. (Note: The temperature of storage rooms can be a bit cooler, especially in winter.)

Underground areas designed to store exhibits, either in vaults or in the open for research and educational purposes, must be properly insulated, especially the structural areas closest to the storage space. They must also have adequate air ventilation to eliminate even the slightest possibility of condensation.

Museums that operate seasonally only (and are usually closed during the winter) are the most vulnerable to damage to their exhibits from an imbalance in temperatures inside and a marked decrease in relative humidity. Museum buildings that are not used in winter should not be cooler than 5°C. It may be preferable to use a humidistat rather than a thermostat as the primary means of control within the given temperature range.

Whenever there is a need to protect artifacts of historic or artistic value, these should be placed in special showcases with built-in microclimatic control.

Excluding the many existing types of heating systems most of which require special care in selection, indoor air stability can be achieved by installing air-conditioning. However, air-conditioning can interfere with the existing structural and architectual integrity of a historic building.

3.2.3 Ultraviolet Radiation

Ideally, all exhibit areas should be illuminated with artificial lighting only. Windows in these areas should be provided with effective ultraviolet (UV) filters, protective blinds and shades. Depending on the type of artifacts exhibited, it is important to accurately regulate the indoor luminosity from 50 lx (for light-sensitive artifacts such as oil paintings or colour fabrics) to 300-350 lx (for less sensitive artifacts). It is also important to group all artifacts requiring an even illumination.

High-pressure mercury and sodium lamps should not be used in exhibit and storage areas because of their poor colour-rendering properties and high UV emission.

4.0 SELECTION OF PROGRAMS

Given all the technical criteria required for planning and selecting programs, museums in rehabilitated historic structures are best suited to modest efforts (for example, displaying special collections of artifacts or, in the case of smaller museums, typifying a local style).

5.0 VISITORS AND CIRCULATION

An imbalanced flow of visitors or their unorganized movement may upset the delicate microclimate, causing physical vibration of floors, dust circulation and the constant release of body heat and moisture. It would be equally dangerous to minimize the seriousness of damage caused by touching artifacts: touching has destroyed many of them. To reduce these risks requires strict rules to monitor and co-ordinate the flow of visitors. A great deal of attention must also be given to the work of maintenance staff, proper functioning of all technical installations and regular daily cleaning of all the rooms and the exhibits.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

5.6

REHABILITATION

HISTORIC GARDENS AND LANDSCAPES

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
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ORIGINAL DRAFT: JOHN STEWART

CONTENTS

1.0 INTRODUCTION

Design and development make up an integral phase in the implementation of a preservation project which involves the conservation of a historic landscape or garden. This phase is reliant on the quality and depth of work which has preceded it. Research, archaeology, evaluation of existing site conditions, contemporary requirements and the preservation philosophy are integrated to develop an approach.

The rehabilitation process stems directly from and is dependent on the findings of historical research and the site analysis (see Vol. III.8 "Investigation and Analysis of Landscapes").

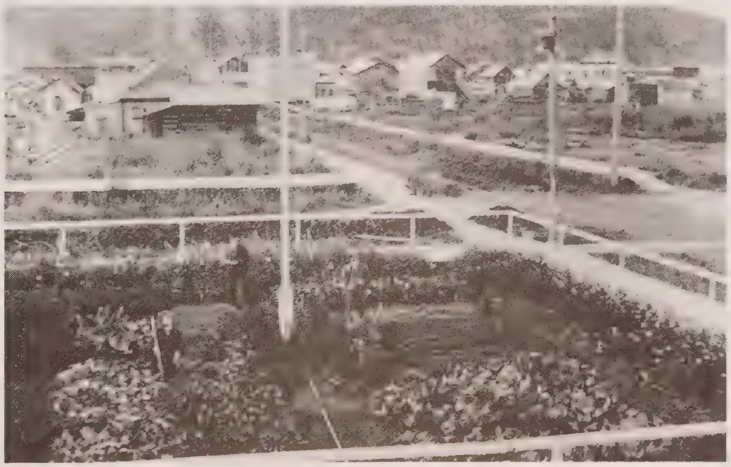
The success of a rehabilitation project relies to a large extent on the appropriateness of the new use. The degree of intervention and the proposed destruction of historical fabric also affect the landscape. The research program is directed towards ensuring the recognition of significant historical elements. An experienced landscape architect familiar with historic landscapes can frequently be depended upon to undertake a suitable rehabilitation program.

1.1 DEFINITION

Rehabilitation is the act or process of returning a landscape or garden to a state of utility through repair or alteration which makes possible an efficient contemporary use while preserving those portions or features of the grounds which are significant because of historic, landscape or cultural value. This is done by means of integrating new components into an existing landscape.

In rehabilitation those portions of the landscape which are important in illustrating historic or design values are preserved or restored. New landscape elements are introduced as part of an adaptive reuse or on a site which requires extensive reconstruction to fulfill its purpose.

This manual will consider new landscape components in the context of contemporary reuse and rehabilitation. The components may have contemporary uses which never existed in the past. Alternatively, they may attempt to duplicate former landscape features which no longer exist. In the case of modern functions the approach to design development is to integrate new elements harmoniously without creating something which appears to have previously existed and which would result in misinterpretation by the viewing public. Replacement of documented but no longer extant elements introduces an entirely different range of questions in the design and development phase. When such features are to be replaced, every effort should be taken to ensure accuracy in recreating the missing component in form, materials and method of construction. (See Vol. VII.2 "Period Sitework" and Vol. VII.14 "Period Landscaping").



Gardening on 5th Avenue
Dawson, YT

1.2 REFERENCES

The material used in the preparation of this relies on the work of Robert Harvey and Susan Buggey, *Time Savers Standards for Landscape Architecture* (Draft was published in 1985); and "Basic Guidelines for the Rehabilitation of Historic Property" (Washington: Interagency Historical Architectural Services Program, National Parks Services, Draft, 1976).

This manual breaks down the landscape into its various components or elements. (See Section 6.3.2 of "Restoration: Historic Gardens and Landscapes."). Each of these components is discussed individually in this manual and is defined in 6.3.

2.0 COMPONENTS

2.1 LANDSCAPE SPATIAL ORGANIZATION

Rather than imposing a new order, rehabilitation should add to and enhance the existing order. In a rehabilitation it is usually impractical to introduce a major new topographical feature. Many of the large elements of a property, such as field patterns and massings of trees, are often retained and reproduced. Berms or buffer plantings are frequently created to mask parking areas or off-site features which detract from the character of the landscape. The original circulation system maybe adapted to serve the contemporary site functions better. An appreciation and understanding of design elements such as building clusters, functional arrangement of a garden area, walkways and the topography can contribute to the rehabilitation.

2.2 CIRCULATION NETWORK

One of the main concerns in rehabilitation is how to successfully meet modern codes for access and circulation without destroying the character of the grounds. Another consideration is how to provide sufficient parking. These needs often create design conflicts and cannot be satisfactorily resolved for all interests. But efforts should be made to reach an optimum compromise using trade offs and other methods of negotiation with the responsible authorities and agencies. The preferred design schemes are those which avoid the need to widen streets, change paving materials or introduce additional paths, roads and parking areas which are not integrated with historical or existing landforms and patterns.

2.3 BOUNDARIES AND ENCLOSURES

A rehabilitation project often results in major changes to the landscape. New uses frequently dictate new functions and patterns. Even if the original circulation pattern and the boundary lines can be incorporated into the rehabilitation scheme, much of the physical site arrangement can be retained. Boundaries and enclosures, more than any other components, dictate the overall pattern and visual understanding of the site. An attempt should be made to reintroduce period fencing materials for the enclosures. If new construction is being introduced, it is important to recognize traditional setbacks and boundary lines in order that all buildings be consistently integrated into their environment.

Inverarden Regency Cottage
Cornwall, ON

2.4 VIEWS AND OTHER PERCEPTUAL QUALITIES

Views and other visually perceptual qualities can play an important part in a rehabilitation. By recognizing and retaining these qualities, either as part of a building's relationship to the landscape (that is, what one sees from a particular window) or how the buildings are clustered to create a wind buffer, the new use can be linked to an original function. These qualities also help to guide the designer in understanding the restraints of the original property. It is these less tangible components which often provide the design key for rehabilitation.

Lower Fort Garry, MB

2.5 GRADES

When introducing new grades or re-establishing earlier site grades, it is useful to have an understanding of period grading practices and aesthetic tastes at various periods. This information can be gained from iconographic sources and period literature. It is important that new grading be looked at in the context of the whole landscape in order to blend with earlier grades and minimize the visual intrusion. The need to make the site features accessible to wheelchairs as well as emergency vehicles can result in grade changes. Similarly the introduction of contemporary services such as septic fields and parking lots can also require drastic grade changes.

Parkwood, Oshawa, ON

2.6 WATER FEATURES

The re-creation of missing water features can require detailed documentation of the earlier feature and precise technical knowledge of construction detailing. The use of modern construction techniques, better suited to modern requirements and maintenance, is advisable. Shoreline details, cascades, dams, pumps and wells should all recognize but not copy the earlier works in form and materials.

New drainage structures may be needed on a historic site as a result of off-site intrusions. Urbanization may have increased the amount of runoff crossing the site. If additional drainage structures are required they should be integrated with the aesthetics of the original system. The runoff should preferably be intercepted before it enters the site.

2.7 PLANT MATERIAL

New plant material is frequently introduced into the landscape for a variety of reasons. Analysis and documentation may show areas where earlier planting has been altered, destroyed or simply died out. It then becomes desirable to re-establish these areas in the light of available plant material and documentary evidence. Modern site requirements introduce new functions that need to be visually screened within the site. Often the surroundings have changed and require the use of peripheral plantings as a buffer.

Whether the new plantings are replacements or are newly introduced, the selection of species should be appropriate. A good understanding of historic planting design styles is essential to successfully prepare a rehabilitation design for a garden or landscape. It is desirable that added plantings have the same stylistic attributes as the original or extant historic plantings to integrate with the character of the existing landscape.

2.8 STRUCTURES AND ACCESSORIES

The majority of new components to be introduced with the rehabilitation scheme onto a historic site will probably fall into the category of original property. It is these less tangible components which often provide the design key for rehabilitation.

New structures and accessories are often required to adapt the site to modern day requirements of adaptive reuse. The kinds of structures which might be required to facilitate modern use include parking areas, visitor facilities, restrooms, informational markers, security systems, fire protection systems, lighting systems and mechanical equipment such as air conditioning

units. Since modern structures and accessories frequently have no precedence in earlier periods of the historic landscape, their introduction often presents problems. These new features are considerably more problematic on a small site than if ample area is available to separate the new from the historic.

External air conditioning units and increased security lighting are examples of new components which usually require camouflaging. Fire hydrants may not have been present during the historical periods being interpreted, but are frequently required to protect the resource. In order to fully serve their intended function, they should not be hidden; hence a design decision has to be made to use a standard style, a special contemporary style or a period style. This type of decision will be needed for all new elements introduced to the historic sites including both the landscape features and the historic structures. This decision should be considered as part of establishing design standards (see Section 5.1 "Rehabilitation: Design Standards").

Pay particular attention to the design of all new components. They should be empathetic with the historic components being preserved, even if contemporary in design, for example, new features can be designed using historic precedent to establish a design vocabulary.

All decisions relevant to new structures and services required to meet modern day demands on historic sites should be considered carefully during the design and development phase to establish their relative necessity, their integration with the existing forms and materials and their aesthetics.

Mature Plant Material

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

6.1

RESTORATION

PERIOD MACHINERY

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: A. WILDSMITH

CONTENTS

1.0 INTRODUCTION

The purpose of this article is to outline the criteria to be considered for the systematic planning and implementation of a restoration program for historic machinery.

The historic site design and development articles listed in the bibliography serve as sources of detailed information required to be read in conjunction with this article.

See Section 6.2 for definitions and the scope of historic machinery restoration.

2.0 PREPARATION FOR THE RESTORATION

a. Investigation:
When carrying out an inspection of the machinery site, prior to commencement of the restoration, basic information should again be noted on location and physical surroundings. See Vol. III.7.1.

b. Access and Utilities:
Note the modes of access to the machinery site and any services required during the restoration.

c. Technical Description:
During the pre-restoration survey, establish such data as name, machine duty, interfacing, type of power (steam, internal combustion, electric, hand) and relative age of each unit. Appropriate terms should be used (Liversidge, 1923).

d. Historical Perspective:
Note major design features. Design aspects that are particularly unique may establish the historical significance of the machines that will be restored.

e. Present Condition:
Following the notations of the design features the person charged with the restoration should note the present condition of the machines and the shelter that protects them. One of the most important factors in the restoration of historic machinery is proper environment. Temperature and humidity should be controlled and harmful pollutants eliminated.

f. Work Crew:
Personnel who will be involved in the restoration should be selected in accordance with the level of difficulty of the task and the unusual or specialized skills required in accordance with the restoration program. When necessary, the selected work crew may be augmented by qualified contractors.

g. Drawings:
Prepare a set of measured drawings of each machine and its layout. These drawings are very important for the preparation of the restoration program.

h. Photographic Coverage:
Photographs record details of the machine that may be removed or altered during restoration. Record work in progress. It may in some cases assist in the preparation of measured drawings.

i. Documentation:
Assemble all documentation related to the history of the site, its present condition and environment and future development or interpretation concepts.

Boiler-driven Pump and Steam Shovel Dredging Material for Sluicing, near Dawson, YT
Courtesy of Anita John's Photo Collection

3.0 RESTORATION OF THE MACHINERY

In general, historic machinery is not required to operate. External cosmetic appearance is the only requirement. This policy also applies to boilers. If any piece of machinery or a boiler is to be put into safe operation, an appropriate testing professional is to be consulted in order to restrict its operation to a level appropriate to the age and duty.

3.1 ADDED STABILIZATION

The person charged with the restoration should see Section 4.7 "Stabilization: Period Machinery" and available reports and drawings for any machines that have previously been stabilized. If inspection of the machinery discloses unsatisfactory conditions all damage and deterioration should be made good.

3.2 CORROSION

Materials used in the repair or replacement of parts of the machinery and associated equipment which are subject to corrosive action should be suitably corrosion-resistant and should be properly matched with respect to galvanic effect.

3.3 TECHNIQUES

Whenever possible the techniques and materials used shall be the same as would have been applied in the appropriate period.

3.3.1 Curatorial Staff

There should be constant consultation with curatorial staff to ensure correct dimensions and detailing of machine fittings, painting, etc.

3.4 PRIORITY SEQUENCE

A clear sequence of priorities for the entire restoration process should be established before work begins by the project manager in consultation with technical staff.

3.5 STRIP-DOWN OF MACHINERY

With photos, research documents and manufacturers' working instructions and parts lists at hand, carefully remove all exposed non-period components, tag items with necessary identification, preserve and put away. The machine should be stripped completely in a methodical order and each component suitably stamped so that it will be replaced in its proper location. At this time, arrangements should be made with other members of the project team to buy or recreate items required for later insertion.

3.5.1 External Cleaning

When all flaking paint, grease and other foreign matter has been removed, wash surfaces with a mild detergent.

3.5.2 Internal Cleaning

All internal parts should be cleaned with an oil-based cleaning solution, to remove oil sludge, rust spots and dirt. When surfaces are dry all, contact surfaces and sliding parts should be inspected for wear ridges, burrs, measured for working clearances, fits and alignment in order to re-establish their original function. When the person charged with the restoration is satisfied that all components are prepared with a selected non-hardening grease and are gathered together, the machine should be reassembled.

3.6 REASSEMBLY OF MACHINERY

With identification witness marks matched, reassemble the machine with special care given to threaded items, gaskets, piston and seal rings, packing and gauges. After assembly, all exposed metal surfaces – with the exception of exposed bright work such as steel piston and valve rods, copper, brass and aluminum – should be treated with a rust inhibitor and then painted. For the selection of paint or coating to be applied to the external surface, consult the conservation laboratory.

4.0 BOILERS

With reference to both the water tube and fire tube boilers, see Section 4.8 "Stabilization: Period Vessels." It is recommended that the procedures outlined in Section 7 be repeated; additional damage, deterioration or corrosion found should be made good and the boiler closed up in good order. External painting of the boiler casing and other non-metallic external boiler items, should be carried out as directed by the conservation laboratory.

Eduction Pipe for Steam Engine
MacDonald's Pumps, YT

5.0 MACHINERY AND BOILER INTERFACINGS

a. Piping
All fuel, water (salt and fresh), lubrication and steam piping should be disconnected at convenient joints and internally cleaned by employing high pressure air. Coat these surfaces with a selected rust inhibiting agent. Remake all joints with appropriate jointing material, packing, etc.

b. Valves
Where a requirement exists, for interpretation purposes, for valves to function they are to be opened for examination. All defects found should be made good and boxed up in good working order. *Note*: In the case of valves being below the water line in vessels that are afloat, this work is not required. Instead these valves should be lashed shut.

c. Machinery Grease and Oil Containers
All grease cups and oil reservoirs required to supply lubrication to moving parts are to be filled with the selected agent. Be satisfied that the friction surfaces are receiving lubrication.

6.0 FINAL REPORT

At the earliest possible moment, document the machine, boiler and interfacings with both photographs and measured drawings. Record both before the unit has been dismantled and when reassembled. Save samples of all discarded material. The analysis of dirt and other wasted matter could be important for documenting the history of the machine boiler or interface.

7.0 MAINTENANCE

Prepare a maintenance schedule for each and every machine and boiler based on the condition of the unit after completion of the restoration. This should indicate the type of maintenance, the type of review for deterioration and all other information necessary to ensure that the historic machine and boiler will be protected.

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VOLUME IV

HISTORIC SITE DESIGN AND DEVELOPMENT

6.2

RESTORATION

PERIOD VESSELS

PRODUCED BY:
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ORIGINAL DRAFT: A. WILDSMITH

CONTENTS

1.0 INTRODUCTION

The purpose of this article is to outline the criteria to be considered for the systematic planning and implementation of a restoration program for historic vessels.

The historic site design and development publications listed in the bibliography serve as sources of detailed information required to be read in conjunction with this article.

Restoration

1.1 DEFINITION

Restoration involves the application of techniques designed to recover the form and detailing of an earlier period in the vessel's evolution. Techniques include the removal of later additions, the stabilization of surviving period fabric and the replacement of missing original elements. In addition it includes repairing or re-creating finishes, decorative features, structural forms and detailing. Whenever possible the techniques and materials used shall be the same as would have been applied in the appropriate period.

1.2 SCOPE

Restoration is generally an independent project activity, based on detailed on-site findings, short-term stabilization and extensive supporting historical research. It can be carried out by the Headquarters Machines & Vessels Section, Heritage Conservation Program (HCP); contracted out to a consultant or carried out entirely by the responsible manager and staff. The arrangement depends on the scope and complexity of the work to be accomplished and the skills and availability of the required resources.

2.0 PREPARATION FOR THE RESTORATION

2.1 INVESTIGATION

For procedures on investigation of a vessel, see Vol. III.7.2. A complete investigation of the site and setting comes within the scope of an environmental analysis (see Vol. III.9). When carrying out an inspection of the vessel, prior to commencement of the restoration, basic information should again be noted on location and physical surroundings.

2.1.1 Design Team

Consult frequently and regularly with the other members of the project design team to ensure correct dimensions and detailing of fixtures, fittings and paintings. Curatorial, material culture, interpretation, historical research and conservation disciplines need to provide conservation advice and assistance to the A&ES design staff.

2.1.2 Physical Environment

Note the berth and other features of interest, the characteristics of the vessel and important climatic data that may affect the restoration.

2.1.3 Access and Utilities

Note the modes of access to the vessel and any services required during the restoration.

2.2 TECHNICAL DESCRIPTION

During the pre-restoration "survey" establish such data as: name, type of vessel, materials, type of construction, layout, number of cargo holds, superstructure, machinery and boiler spaces, type of power, engine drive and propellor, where built, when launched, its length, depth, beam, draft, both tonnages, framing systems, type of bulkheads and relative age of the

different fixtures in the vessel. Appropriate terms should be used. Reference – *The Mariner's Dictionary* by Gershom Bradford, 1972.

2.3 HISTORICAL PERSPECTIVE

Note major design features. The design aspects that are particularly unique may establish the historical significance of the vessel. Make note of the date and sequence of the vessel's construction, any signs of past alteration, additions and modifications.

2.4 PRESENT CONDITION

Note the present condition of the vessel, its components and materials. Establish relative rates of decay (e.g. damage to wood by mechanical fastenings, fastenings damaged by galvanic action) and effects of differential movement between materials.

2.5 WORK CREW

All restoration work should be undertaken by experts familiar with the class of historic vessel being restored.

2.6 DRAWINGS

Prepare a set of measured drawings and site plans. These not only form records of existing conditions; they are of paramount importance for management of the restoration work.

2.7 PHOTOGRAPHIC COVERAGE

Photographs record details that may be removed or altered during restoration. Record work in progress. Photographs may assist in the preparation of measured drawings.

2.8 DOCUMENTATION

Assemble all other documentation related to the history of the vessel, its present condition and site and concepts for development and interpretation.

3.0 RESTORATION OF VESSEL

3.1 GENERAL REMARKS

It is the practice of the Canadian Parks Service (CPS) and other heritage conservation organizations not to put historic vessels into service. To this end, appearance and long-term preservation are the primary requirements; there is no unnecessary demand for machinery components to move or rotate and, if applicable, boilers to be flashed. However, if the vessel is to return to active service, both Ships Safety Canadian Coast Guard (SSCCG) and Classification Society must be consulted in order to bring the vessel up to present standards, for safe operation and safe sailing in weather and conditions suited to the vessel's age, size and type.

Getting Correct Shape for Decking

3.2 SEQUENCE OF WORK

The sequence of work to be carried out on the ship should be clearly established at the outset by the project manager in consultation with technical staff.

3.3 ADDED STABILIZATION

The person charged with the restoration should refer to Section 4.8 "Stabilization: Period Vessels," and to available reports and part ship drawings if the vessel has previously been stabilized. It may be determined through inspection that some of this work must be redone or that new areas of damage or deterioration must be made good.

3.4 OVERLOADING AND DEFLECTION OF HULL STRUCTURE

In order to prevent permanent hull deflection, do not overload any part of the vessel.

Keep records on the deflection of the vessel at different stages during the restoration. The values of these readings should be to a high degree of precision.

The readings should be taken:

a. immediately before work has commenced;
b. 48 hours after work has commenced; and
c. every 48 hours until the completion of the work of a trade which could affect load conditions.

3.5 CORROSION

Materials used in the restoration work should be properly matched and treated to reduce the chances of corrosion.

3.6 CUTTING, PATCHING AND NEW WORK

Cutting, patching and new work should conform to the applicable part ship drawing.

Areas of holes and flaws that exist and sections of missing timber or steel in the vessel as well as types of remedial work, should be reflected on the applicable drawing.

All new wood and steel should conform to good ship repair standards (kiln-dried wood and coated rust free steel).

3.7 WOODEN HULLED VESSELS

The person charged with the restoration should, with the appropriate documentation, remove all non-period items and chemically treat the areas where the component had been fitted. Make arrangements with the other members of the project team to buy or recreate fittings and furnishings that will be required for later installation.

The ship should be strengthened as necessary, by replacing, treating or sistering. Check beams and butts on transom and stem. Repair all depressions in planking, replace all damaged fastenings, replace or repair deck planking, and caulk and seal with oakum and pitch.

All exposed wood that may be subject to wetting should be treated with a suitable preservative. A solution must be chosen which will not leach out and cause contamination if the vessel is to be floated.

3.8 STEEL HULLED VESSELS

With appropriate documentation, remove all non-period items, clean and prime-coat areas where components had been seated. Arrangements should be made with other members of the project team to buy or re-create fittings and furnishings that will be required for later installation.

The ship should be strengthened, as necessary, by repairs, replacement of steel structural components, making good excessive corrosion areas, cracked welds, plate seams, cracks around rivet heads and riveted lap seams in riveted construction vessels.

Fishing Vessel Rigging

3.9 SHIPS RIGGING, FUNNEL AND GUYS

With relevant drawings of the ships rigging and hardware check over existing rigging. Remove non-period components,

refurbish, as necessary, mast, standing rigging, running rigging and hardware. Replace missing units with accurate replacements. Thoroughly clean all surfaces and apply suitable coatings. With reference to the funnel and guys, steel work on the outer surface and guys are to have all scale and other foreign matter removed and corroded areas made good with a base coating applied as required; an oil-base preservative should be applied to the guys and hardware.

3.10 SUPERSTRUCTURE

The complete superstructure should have all non-period section/components removed. The remaining structure should have a suitable preservative applied to arrest deterioration. Significant rebuilding should be done in such a manner that it conforms to the structure's original appearance. New materials for reinforcement and new fastenings should be concealed or designed to avoid intruding on or deterring from the historic environment unless concealment would result in a major alteration or destruction of historically significant materials or spaces.

3.11 MACHINERY AND BOILERS

For technical considerations see Section 6.1 "Restoration: Period Machinery."

3.12 PAINTING

In carrying out final painting and coating there are no generalizations to follow, especially with regard to choice of colour.

S.S. Klondike, Whitehorse, YT

Fashions change from period to period and the restoration of each ship part should be studied and treated individually. The ship should be repainted in colours appropriate to that period if historic colours are not known.

4.0 FINAL REPORT

The technical person charged with the restoration should document the vessel with both photographs and measured drawings of each ship part before and after restoration. Save samples of all discarded material. The analysis of wasted matter could be important for documenting the history of the vessel.

5.0 MAINTENANCE

Prepare a maintenance schedule for the historic vessel based on the condition of the ship after completion of the restoration. This should indicate the type of maintenance, the inspection requirements and all other information necessary to ensure that the historic vessel will be protected.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

6.3
RESTORATION
HISTORIC GARDENS AND LANDSCAPES

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HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: JOHN STEWART

CONTENTS

1.0 INTRODUCTION

The process of period restoration, which involves putting back as accurately as possible what was once present, stems directly from and is dependent on the findings of historical research and the site analysis. (See Vol. III). The success of the restoration process depends on the capability of the designers and conservators to work with the research findings. One of the prime implications of a landscape restoration is the high degree of intervention required which usually involves removal and replacement. It is necessary to appreciate that a landscape is an ecosystem where change takes place and removal and replacement can be inappropriate. This is most evident when considering plant material, which is constantly growing and changing with time.

1.1 DEFINITION

Landscape restoration is the act or process of accurately recovering the form and details of the various components which together make up a landscape, as they appeared during a particular time. This is normally done by means of the removal of more recent components and the replacement of missing earlier components.

Landscape components frequently differ from the architectural due to their scale, complexity and ephemeral quality. Landscape restoration involves the management of change to a much greater degree than with engineering or architectural works. As a result of the dimension of time and the natural changes that occur, rehabilitation and restoration practices are often interwoven into the design and development activity. Management of a historic garden or landscape should provide for controlled change while protecting the components. The aspects of maintenance are dealt with in Section 3.4 "Interim Protection: Historic Gardens and Landscapes" and in Vol. V "Historic Site Maintenance."

In defining the activities of design and development when applied to historic landscapes, it is necessary to look at the interrelated material components. These are set out in this article according to scale, from large to small. Not every activity is evident in every historic landscape, but all should be considered in the initial identification, as a part of the analysis of historic landscapes (Vol. III), in the recording phase (Vol. II), in the design phase, in the development phase and in maintenance (Vol. V).

The following section discusses these components in the context of the restoration process.

1.2 REFERENCES

The material used in preparation of this manual draws heavily on the work of Robert Harvey and Susan Buggey, *Time Savers Standards for Landscape Architecture* and Robert Melnick, *Identifying, Evaluating and Managing Vernacular Landscapes in the National Park System: A Technical Manual.* In both studies the authors are concerned with the conservation of landscapes and gardens. The appraisal and the preservation of landscapes is dealt with in terms of elements (Harvey and Buggey) or material components (Melnick) which make up the landscape. In the same way that a building is broken down into its component parts, starting with the roof and going down to the foundation, the landscape or garden can be appraised by components. Each of the component parts is discussed and the appropriate restoration approach is presented.

Landscape – Aerial View
Central Experimental Farm, Ottawa, ON

2.0 COMPONENTS

2.1 LANDSCAPE SPATIAL ORGANIZATION

This component relates primarily to the large overall patterns of the cultural landscape. It deals with broad planning issues, the large-scale relationships among major components and predominant land forms such as hills or ridges. Site clusters, field patterns, earth works, military battlements, canals and other waterways are types of land use activities which were imposed upon and which occupy large portions of the landscape and reflect its organization. Recognizing how these physical forms encouraged and dictated the evolution of site development is essential in assessing the totality of a landscape.

The topographical features and major landscape components should be appraised as to their overall importance to the site's historical uses. Land forms off the immediate site are frequently important adjuncts which should be documented and protected. Evidence of the landscape spatial organization can be seen using aerial photographs, topographic plans and on-site inspections.

Natural features such as mountains and rivers and material components such as roads and field systems can be mapped as a composite with overlays. (For a more detailed explanation see Vol. III. 8 "Investigation and Analysis of Landscapes.") The direct relationships between the landscape components and relevant natural features should be noted. Where possible these relationships should be preserved. This will likely involve the use of preservation legislation and other land use controls. The restoration may need selective replanting or large-scale reforestation off the site in order to re-establish visual relationships or screen out intrusions.

2.2 CIRCULATION NETWORK

Circulation networks range in scale from footpaths to highways. Networks may be internal to a specific landscape or they may connect that landscape to the surrounding area. For example, the Rideau Canal system is both a circulation network and also defines the landscapes' spatial organization, land patterns and settlement patterns. All circulation systems facilitate movement from one point to another.

In the restoration of a period circulation system care should be taken to utilize traditional materials as well as preserving the historic dimensions. As a result of today's design codes and in response to modern services and vehicles, it is often necessary to modify the location and physical structure of roads and paths. This is discussed in Section 6.3 "Rehabilitation: Historic Gardens and Landscapes."

2.3 BOUNDARIES AND ENCLOSURES

Boundaries and enclosures set out the perimeters and identify and delineate areas of control and use, either for the overall site or for segments of it. They may take the form of fences, hedges, walls, gates, tree lines or natural barriers. Period documents should be consulted in order to understand the land ownership and land use. Site recording will often provide evidence of historical materials, construction, vegetation and conditions.

Boundaries

In a restoration project the reinstating of boundary demarcations and enclosures is extremely important to the overall understanding of the site. Because they form the walls, dictate

spatial organization and reveal the original design intent, their placement and materials are important in restoring a property to a certain period. Every effort should be made to reuse the original fabric for fencing. However, to ensure longevity it is advisable to use pressure treated material for fence posts and other ground contact situations when these are being replaced.

2.4 SITE ARRANGEMENT

The site arrangement is the internal placement of elements such as plant material, fences, paths and buildings within a discrete landscape setting. The site arrangement provides much of the historic significance, gives information on the impact of various technologies and offers a fuller understanding of landscape styles.

The restoration of a site necessitates the preparation of an overall physical development plan which specifies which of the elements are to be incorporated into the scheme, what sizes they will be and how each feature will relate to the other site components. The site arrangement and condition dictates zones to be restored, components to be removed and the steps that should be taken in order to restore the grounds and structures to a certain arrangement reflective of the period(s) being interpreted.

2.5 VIEWS AND OTHER PERCEPTUAL QUALITIES

The assessment of visual and perceptual characteristics is not a clearly defined component. Views or vistas which were present in past gardens and landscapes should be identified. Often they will explain original site selection orientation of buildings and arrangements of other site features. Views from the front door, from windows or from known viewpoints in the landscape are temporal in nature, but their restoration is an interesting means of recreating the mood or character which an earlier inhabitant had possibly experienced. For example, an accurate period restoration for 18th- or 19th-century sites requires that particular attention be given to the historical perceptions of 'picturesque'. This perception dictated art form, literature and the treatment of landscape. Views to adjacent landforms, such as water features or distant hills, were often intentionally incorporated into the landscape design. Where possible these vistas should be retained and, where missing, reinstated. The latter is more often the case where more recent planting or structures intrude onto the views of a period landscape.

2.6 GRADES AND TOPOGRAPHIC FEATURES

Site contours or grades are an essential characteristic of a historic property. The restoration of a landscape takes into consideration the protection and retention of grades which have been documented during the recording phase. Often remedial work is required around the foundations of historic buildings. Similarly the need for heavy machinery on the site can damage the grounds and make remedial work necessary.

Mackenzie King Estate
Kingsmere, PQ

During the restoration of a garden or landscape, the contours should be well documented and related to several permanent survey markers providing horizontal and vertical control before undertaking any grading changes. Re-establishing earlier site grades should be done without a massive overhaul of a site unless this is absolutely necessary. Regrading will have an adverse effect on the root system of mature trees and shrubs. The relationships between site features will have to be assessed carefully before work begins. Where grading takes place on a site to restore original forms, it should be carried out under the direction of a person who has an understanding of historic grading practices and knowledge of the aesthetic tastes of the period and area being restored. Similarly the restoration should recognize maintenance practices.

2.7 WATER FEATURES

Water features on a historic site should be preserved and restored if possible. Canals, irrigation systems, ornamental fountains, wells and pumps offer considerable potential for period interpretation.

As with grades and plant material, existing water features have often been changed. An important determinant in undertaking a restoration is the availability of information. It is essential that all data concerning a water feature be compiled, particularly if a mechanical system was involved. There is a need to involve other professions besides landscape architecture when making recommendations. It is questionable whether to reinstate a period detail that was originally unsuitable with the same detail, only to have it fail one more time. As with all aspects of a restoration, such a situation should not be looked on as giving licence to alter the character of the feature in order to arrive at a "better" solution to the problem. The development of a satisfactory restoration solution calls for the integration of the period design details with the requirements of the new components in a way that the feature is not appreciably modified.

2.8 PLANT MATERIALS

While many components of a garden or landscape change over time, vegetation is perhaps the most dynamic. Developing an acceptable approach to the integration of existing plant materials is the most difficult aspect of the design development phase. The varieties of plant material used and their arrangement can provide an excellent record which rarely represents a single time period.

The vegetation will have matured to a greater or lesser extent through time and natural actions and new varieties of trees and shrubs will have been added.

It is important that the original intent of the designer be understood. Often the sun-filled perennial garden has become dank and shaded as a result of maturing trees. The conservator must face the quandary of assessing the designer's original intent against the actual plantings which were put in and the surviving plant materials in a mature state. Are the existing trees and shrubs, overgrown as they are, too valuable to remove? What should be done with vegetation which is in good condition but does not relate to the period to which a site is being restored? These questions have no simple answer and must be assessed on an individual basis on their own merit.

Once a terminal date or time period has been selected for the restoration, the landscape architect should prepare a preliminary planting scheme and begin a program of research and acquisition. This will involve locating and propagating plants appropriate to the period. An important factor with respect to period plant materials is their availability from nursery stock. Older plant varieties are not readily available and so it is necessary to locate specialty suppliers. Existing plants found on the site can often provide good stock for replanting. A certain amount of material will be available through the landscape archaeological program. Material can be obtained from old private gardens. Local garden and horticultural societies may be able to provide expertise and be willing to search out material.

In the design of a restoration scheme it is important to prepare a planting plan which is accurate and representative of the period to which the landscape is being restored. It will sometimes be necessary to make substitutions, but this should be done only after the search has been exhausted. A program of replanting and propagation should be developed as a part of the development stage. The formation of an on-site nursery is often an advantage when plant material is being collected over an extended period of time.

2.9 STRUCTURES AND ACCESSORIES

Architectural and structural elements as well as additional accessories are important adjuncts to any historic garden or landscape. These elements give the site added interest. Ancillary structures and accessories also require restoration techniques.

Extant structures and accessories should be carefully restored in accordance with the philosophical objectives guiding the landscape work. Appropriate treatment of the structures and accessories will normally require expertise in historical materials conservation such as masonry, wood, metals, paints and plaster.

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VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

7.1
SPECIAL TECHNIQUES
DISMANTLING AND REASSEMBLY OF WOOD STRUCTURES

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ORIGINAL DRAFT: K. BARDELL

CONTENTS

1.0 INTRODUCTION

This article describes the dismantling and reassembly process for the conservation of wood structural systems in historic structures. This process is a severe form of intervention to be considered only when in situ treatment is not feasible.

2.0 APPLICATION

The technique of dismantling and reassembly is applicable to the following types of timber construction with the given constraints:

a. palisade and horizontal timber walls and particularly applicable to "pièce-sur-pièce";
b. heavy timber wall framing and interior support systems (post and beam, trussed timber partitions) and particularly applicable to mortise and tenon work; and
c. for light timber framing there is limited application because damage to connections is unavoidable.

The scope of application ranges from individual wall panel treatment, to full floors, walls or interior bearing systems, to entire structures. Basic techniques are applicable in all cases.

3.0 REASONS FOR ACTION

Dismantling and reassembly is carried out to allow conservation treatment of the unit to be dismantled and/or adjacent and supporting units.

Severe deterioration in the unit itself is the usual justification. Potential problems include fungal and insect attack, fire damage and deformation due to seasoning or foundation movement. Structural weaknesses inherent in the original design can also cause deformation and/or mechanical failure necessitating dismantling. Possible design faults include undersized members, poor connection detailing, lack of supports for floors, modification of interior bracing systems, removal of diagonal bracing for the insertion of door and window openings, reduction in section of beams at critical points for service chases and the imposition of new floor loads.

Other justifications for dismantling include:

a. preservation of an otherwise inaccessible part of a structure;
b. preservation of a finish intact; and
c. moving of an entire structure or unit to another site.

4.0 GENERAL CONSIDERATIONS

4.1 LEVEL OF INTERVENTION

During the dismantling and reassembly process a structural unit or building loses architectural integrity which cannot be restored. Architectural evidence can also be destroyed which reduces the value of the building as a record for future researchers.

Structurally, an element in place in a structure for any length of time becomes part of the structural entity and its removal destroys a certain plastic equilibrium. A reassembled unit or structure will not behave identically with the original. It may also be that a partially deteriorated unit such as a log wall which is still functioning as an element in a structure may contain, when dismantled, little timber of recoverable structural value and essentially a new unit must replace it.

These factors must be considered when selecting the dismantling and reassembly process.

Other available techniques include:

"Splicing and Repair," Section 4.2;
"Chemical Consolidation," Section 4.2.1; and
"Chinking," Section 4.2.2 – all in this Volume.

4.2 ADVANTAGES

a. With dismantling and reassembly, full treatment of individual components is possible, including connections.
b. Access to problem areas is provided which may in the long run preserve more fabric, if decay is completely arrested.
c. As an investigative technique, it may uncover hidden evidence giving structural and architectural information about the building's history.

4.3 COST CONSIDERATIONS

a. This technique may save time and labour costs by avoiding the need for in situ specialized treatments.
b. Elements can be shipped for treatment if necessary.
c. It may also avoid future costs by allowing more complete control of the causes of deterioration.
d. Extra costs will be incurred because of the need for accurate recording and material handling.
e. Additional costs will normally be incurred for new materials and reconstruction activity because of the loss of finishes and other features.

5.0 PHASING

A schedule for the entire dismantling and reassembly process should be drawn up before the work begins to ensure the best use of labour and equipment. Other conservation work on site should be integrated with the activity (conservation of finishes, foundation work, etc.). An architectural model may prove useful in determining the order and units of dismantling.

The four major phases for scheduling are: dismantling, interim handling, reassembly and maintenance/follow-up.

Model for Structural Analysis

6.0 DISMANTLING

6.1 ENGINEERING ANALYSIS

A complete engineering analysis of the unit to be dismantled should be carried out. Analysis should be directed towards determining causes of deterioration, changes in the unit as a result of the defects, role of the unit in a larger structure, where applicable, including connection details and bracing considerations. The analysis should provide justification for the dismantling technique.

6.2 RECORDING

Dismantling of a unit is destructive and accurate recording is therefore essential. A complete record of the unit should be made using a combination of photography (especially stereophotogrammetry) and hand recording. The recording process should consider the orientation of elements and connection details.

Individual elements should be numbered before removal. The numbering system should be logical and systematic and coordinated with the record drawings. The following considerations apply.

a. For large projects, the total area should be subdivided and the subdivisions included in the numbering.
b. Tools and methods for numbering are a function of later visibility of the elements and the length and type of storage anticipated. A recommended system is the use of metal tags nailed at either end of each member. Other possibilities include scored markings and pencil. Numbering must be removable without damage to exposed surfaces.
c. Two parallel sets of numbers should be used on each element and referenced separately.
d. For easily visible markings, the structure should be photographed and numbered.

6.3 SHORING AND BRACING

Bracing will be required when the dismantling is carried out in an order different from the original construction process or when deterioration is advanced. Details of the design are a function of the scale of work and the type of unit.

For technical information, see Section 3.2 "Interim Protection: Stabilization of Historic Structures.

Shoring

6.4 REMOVAL OF ELEMENTS

The following considerations apply to the dismantling itself:

a. Load transfer from unit to bracing or to rest of structure should be slow, smooth and continuous.
b. Destruction of historic fabric must be minimized. If connections are to be cut, less visible elements should be cut first. Where possible, the connectors can be removed intact.
c. Finishes should be preserved where possible:

- clapboarding – remove separately
- chinking, wattle and daub – obtain representative samples
- paint and other coatings – ensure non-destructive handling.

d. Wherever connection details, construction type and equipment available permit, units such as windows, door assemblies and wall panels should be removed in one piece.
e. Reuse should be made of any original wall assembly features such as notches in uprights for sliding horizontal members.

6.5 EXAMINATION

Immediately after dismantling, examination and recording of the unit, its elements and the parent structure should be carried out with regard to:

a. hidden biological deterioration and structural weaknesses;
b. hidden evidence of construction detailing;
c. hidden evidence of architectural features and modifications, including partition markings, window and door evidence, uncovered mortise holes, etc.; and
d. sampling of all finishes not previously taken.

7.0 INTERIM HANDLING

7.1 INFORMATION MANAGEMENT

An accurate inventory must be maintained of all dismantled elements. It should be continously updated to reflect location and treatment. For large projects, computer based systems may be required to coordinate movement and processing.

7.2 CONSERVATION TREATMENT

Individual elements can be treated on site or by shipment to a treatment facility. Such measures as application of preservatives, internal reinforcement and partial replacement and splicing may be required.

7.3 STORAGE

The goal of proper storage is the preservation of structural condition and architectural evidence. Storage patterns must be systematically related to the dismantling and reassembly procedures, in order to make efficient use of equipment, labour and space. The following considerations apply.

a. Transportation of elements is a part of the storage process and should be planned as such.

b. Theft, vandalism and loss can be a severe and unanticipated problem.
c. Storage patterns should relate to the element numbering system and protect the numbers themselves. Connections should be stored with related elements – windows and doors as a unit, etc.
d. Minimal protection should include adequate ventilation and shelter from the weather.

Storage is a well defined labour-intensive task and clear stipulation of this fact should be made within a contract or specification.

7.4 TREATMENT OF PARENT STRUCTURE

If the dismantled unit is part of larger complex, the parent structure should receive the following treatments:

a. preservative treatments and mechanical repair of exposed defects;
b. preventive treatment to ensure no repetition of problems within the unit; and
c. preparative treatments to accept the reassembled unit and its new behaviour.

8.0 REASSEMBLY

The order of reassembly should be the reverse of dismantling, if possible.

a. scheduling must be predetermined;
b. units of reassembly may be larger than those in dismantling and appropriate equipment provisions should be made;
c. elements should be reassembled exactly as dismantled unless conservation measures dictate otherwise (e.g. turning the weather face of a log or column 90 degrees);
d. removal of bracing should be slow and balanced with provision for rebracing if unanticipated failure occurs; and
e. historic fabric must be protected during fastening and numbering system removal.

9.0 MAINTENANCE/FOLLOW-UP

Within the scope of an overall project dossier maintained throughout the conservation process, the following elements of the dismantling and reassembly procedure should be recorded:

- progress photographs
- recording of new evidence
- drawing of all new materials, connections and details incorporated into the reassembled structure

A maintenance program should be designed, with special attention to possible maintenance requirements for new materials or expected new behaviour. A monitoring program may be required in the early stages to detect unsuspected evidence of decay or deformation.

VOLUME IV
HISTORIC SITE DESIGN AND DEVELOPMENT

7.2
SPECIAL TECHNIQUES
MOVING HISTORIC STRUCTURES

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CONTENTS

1.0 INTRODUCTION

"Housemoving" is a delicate operation but moving historic buildings is more demanding. Even the smallest, most flexible structure has elements that will be damaged by racking, twisting or some other effect of movement. Although building relocation is usually viewed as an engineering feat of great significance and never fails to attract a great deal of attention, most are, in fact, routine. In many parts of North America, particularly in rural areas, the task is accomplished with relatively little difficulty using basic or even homemade tools and equipment.

On the other hand, moving complex or oversized structures of considerable mass within the core of a city is a highly specialized task requiring the use of sophisticated technology, skilled personnel and experience available only from an expert contractor.

The process of separating a building from its traditional site and context is a severe form of intervention to be considered when there is no alternative.

1.1 PURPOSE

This article describes the techniques of lifting and moving small buildings such as residences and agricultural buildings. It describes in detail the technical aspects of the work for those personally involved in moving this type of building. It will also be useful as background information for co-ordinators of projects that involve the use of contractors to plan and execute the relocation of more complex structures.

2.0 BUILDING RELOCATION CHECKLIST

Relocating a building, particularly by contract, involves a lot more than hiring a contractor, particularly if the building is going to a new site. The following checklist is for managers of building relocation projects. It assumes that research activities of other disciplines have been appropriately involved and co-ordinated.

2.1 PART 1: FEASIBILITY

a. Alternatives:
Determine if there are alternatives to relocating the building that would achieve the same end, for example, purchase of building and site, establishment of easements.

b. Designation:
Relocating the building will jeopardize Historic Sites and Monuments Board (HSMB) or other designation.

c. Site:
Is a new site with good access, acceptable zoning and all required services available?

2.2 PART 2: COST ESTIMATES

a. Mover:
The moving contractor's written estimates should include a description of the method to be used, the extent of insurance coverage and a detailed statement of inclusions and exclusions.

b. Demolition:
Estimate the cost of removal of the old foundation and backfilling. If some foundation materials are required on the new site this should be included.

c. Construction:
Estimate for construction of the new foundation, excavation and drainage. If required the reuse of materials in the design should be specified.

d. Documentation:
At the very least a detailed record of the building plan and elevation will be required for construction of the new foundation. All materials, details, patterns and other aspects of the building that will be interfered with by moving operations should be carefully and accurately recorded.

e. Utilities:
Fees for disconnection and reconnection of water, gas, telephone and electricity should be determined.

f. Other fees are:

- trimming trees for clearance
- moving street, traffic signs and other obstacles
- moving power lines
- insurance (if not provided by the contractor)
- traffic control

- property acquisitions fees such as title searches and surveys
- bonds may have to be posted before permits are issued

2.3 PART 3: PRE-RELOCATION

a. Title:
Obtain title to the property and insurance.

b. Site:
A detailed site plan is required even if the foundation is to be constructed after relocation of the building. Excavation will probably precede the relocation.

c. Permits:
Ensure that all building and demolition permits will be granted by the date required. Ensure that there will be no impediments to obtaining the transportation permit by the contractor.

d. Contracts:
Specifications, contracts and tender prices with the relevant bonds and insurances should be completed and signed.

e. Insurance:
Obtain insurance for every aspect of the relocation. For example, joint liability, property loss and liability. The scope and terms of the contractor's insurance will be limited.

f. Traffic Control:
Advise police of the proposed move, particularly if an escort and traffic control are required at any phase of the relocation.

2.4 PART 4: POST-RELOCATION MATTERS

a. Security:
Ensure the building is properly boarded and secure.

b. Demolition:
Demolish, backfill and grade the old site. Arrange for archaeological investigation if required.

c. Foundation:
Construct the new foundation under the building.

d. Other Items:
Revise property insurance of the building.

3.0 DOCUMENTATION

3.1 ARCHAEOLOGY

Archaeological investigations of the building environs should precede any excavation on the site or under the building. The purpose of these investigations is to uncover objects and information pertaining to the building or its occupants that may be lost as a result of the relocation. Archaeology may also produce information about previous appendages to the building and site features.

If the move is permanent it is also advisable to conduct an archaeological investigation of the site to which the building is being moved.

3.2 RECORDING

Relocation of a building is destructive of historic fabric and details. Some elements of the building such as the foundations may not be included in the move. Accurate recording of the building and site is therefore essential. A complete record of the structure should be made using a combination of hand and photographic methods.

A full recording is preferred. However, if resources are limited selective recording may be acceptable. Such a program should be identified by the project architect, engineer and heritage recorder. It should identify the components, assemblies, details and connections to be recorded in detail based on potential for loss or disturbance during the relocation work.

Heritage records will stand as an archival record of the building in its existing form, on its original site. Accurate records are also required for the design and construction of the new foundation to ensure that the building, when on the new foundation, retains its historic elevation in relation to the site elevation.

3.3 INVESTIGATION AND ANALYSIS

Full investigation of the building by an architect and engineer will determine the structure of the building, causes and types of deterioration and identify evidence of the history of alterations to the building. The investigation will also identify requirements for reinforcement, bracing and protection of historic fabric during the move.

4.0 PROTECTION AND REINFORCEMENT

Most building relocations or temporary moves require interim structural reinforcement to resist unusual stresses and minimize damage to the fabric. This reinforcement should be external to the fabric of the building to keep damage to a minimum. The extent of reinforcement required varies considerably.

Heavily deteriorated and deformed buildings require a full rigid box frame within the building for lifting and moving. In effect the building hangs over the box frame and this frame provides a support extension on which the moving operations can be based. Such a frame freezes the building in its deformed state until after the relocation work is completed. For further technical information on types and design of interim reinforcement and bracing refer to Section 3.2 "Interim Protection: Stabilization of Historic Structures" and Weil and Kosceilecki, "Report on Interim Protection and Stabilization Techniques," Klondike National Historic Sites, 1972.

5.0 DISMANTLING AND REASSEMBLY

Moving a building intact is always preferable to moving it in pieces. Dismantling is structurally disruptive, involves the loss of considerable quantities of historic fabric, requires detailed recording and the entire process is labour intensive and expensive.

Size limitations over the route to be travelled are the principal determinant of the extent of dismantling required. As a general rule the further a building is to be moved, the more severe the dismantling that will be required. Extremely large and complex structures require very little dismantling when moved very short distances or when moved on other than public roads.

Partial disassembly usually takes one of two forms:

a. removal of additions and appendages from the main section of the building for separate moving; or
b. separation of the building into its major assemblies – end walls, gable ends, front and rear walls and roof.

Partially dismantling a building simplifies a long distance relocation, allowing it to be moved as normal truck cargo without the restrictions of an oversized load. Extensive recording and careful dismantling and reassembly are necessary, however and these bear high labour costs.

Full dismantling involves the loss of high proportions of historic fabric and integrity. It is a last resort procedure and all alternatives should be considered first.

For futher information on dismantling and reassembly see Section 7.1 "Special Techniques: Dismantling and Reassembly of Wood Structures."

6.0 LIFTING AND MOVING

Two basic methods are used for moving buildings.

a. Track and roller – applicable to short moves or structures of very high mass; level grades are preferred as grade changes must be negotiated in steps.
b. Flat-bed trailer or beam and wheeled dolly – applicable to moves of longer distance over uneven ground.

The following sequence of operations can be applied to most lifting and moving operations.

6.1 INSTALLATION OF LIFTING EQUIPMENT

Excavate around the building perimeter and beneath interior bearing points to make space for lifting equipment. Install additional bracing, walers or hard joints as required for jacking. A trench about 0.6 m wide and 0.5 m deep provides enough space for hydraulic jacks and their supports. The cribs and jacks require a level bearing surface that is best achieved by hand excavation. The use of power equipment should be reserved for major excavations. The use of hand tools close to the building avoids damage to the structure from power equipment.

6.2 PLACEMENT OF JACKS

a. Select points for lifting. Jacks should be installed beneath point loads, load bearing walls and exterior walls. If cribs cannot be installed directly beneath exterior walls use a needle beam and a jack on either side of the wall or across a corner positioned at 45° to each wall. Install stringers, bolted to the temporary bracing frame, to provide bearing points beneath deteriorated wood walls if required.
b. Support all jacks on a platform or crib of timbers beneath the lifting points.
c. Jacks of the 10-20 tonne capacity range are recommended (a small jack will refuse to lift when imposed

loads are greater than the bearing capacity of timber members). All jacks require a steel bearing plate on top to distribute the load across the full width of the timber.

d. Tools and equipment:
   - Jacks: 10-20 tonne capacity hydraulic jacks (a one and one-half storey wood frame residence of 230 m^2 requires 10-12 jacks).
   - Steel bearing plates: 150 x 150 x 12 mm thick plates to be placed between the top of the jack and the wood structure - one per jack.
   - Cribs:
     100 x 100 mm and 150 mm wood crib pieces 1.0 m long are required in large quantities.

6.3 LIFTING OPERATIONS

a. The building is raised in stages equal to the lift of the jacks.
b. Lift uniformly at all points by using a signalling device or a centrally operated multiple jacking system.
c. As the building rises install a timber crib; on each side of each jack install cribs between points where beams will later be positioned.
d. Use plywood plates as shims to raise the jack on its cribbing.
e. For safety, ensure that the jacks and adjacent cribs are supported on a wide, stable base during the lifting operation.
f. The actual amount of lifting required is determined by the requirements of the work to be done, design of the new foundation and space required for its construction if the building cannot be removed from the site, historic relationship with street grade and depth of the lifting beams and rollers. There are two important points in raising any building:
   - plan to lift only once to the correct elevation
   - working drawings must include finished elevations for grade, foundations and floor plus a reference elevation and its location.

6.4 INSTALLING BEAMS AND TRACKS

a. Install beams for additional lifting if required. Beams provide more uniform support than cribs, require fewer jacks and more even lifting. Beams should be installed as soon as there is space to do so.
b. Secondary beams or an entire chassis can be installed between the lifting beams and the building if required.
c. If track beams are to be used to move the building install them at the same time as the lifting beams. Track beams should be firmly supported on widely based cribs.
d. Level all track beams perfectly. Ensure that all tracks are parallel and braced in position to ensure they do not move.
e. Install pipe rollers between the lifting beams and the track beam.
f. Tools and equipment:
   - Jacks: hydraulic jacks and ratchet jacks (step jacks) for positioning beams
   - Beams: 300 mm wide flange or 200 x 300 mm built up wood beams, Douglas fir
   - Track beam cross bracing: 100 x 100 mm with 17 mm ply gussets; use two-headed nails for easy dismantling
   - Rollers: 38 mm dia. galvanized steel pipe, 300 mm long

6.5 MOVING THE BUILDING: BEAM AND TRACKS

a. Use cable jacks to pull the building off the site. The jacks are anchored against a parked vehicle or other immovable object, one per beam. Two people working in unison, operate each jack to draw the building along the track.
b. Lateral directional control is maintained by angling the rollers with a steel bar.
c. Tools and equipment:
   - cable jacks and wire cable
   - steel bar: a wrecking bar of steel 1.5 m long for angling and adjusting pipe rollers

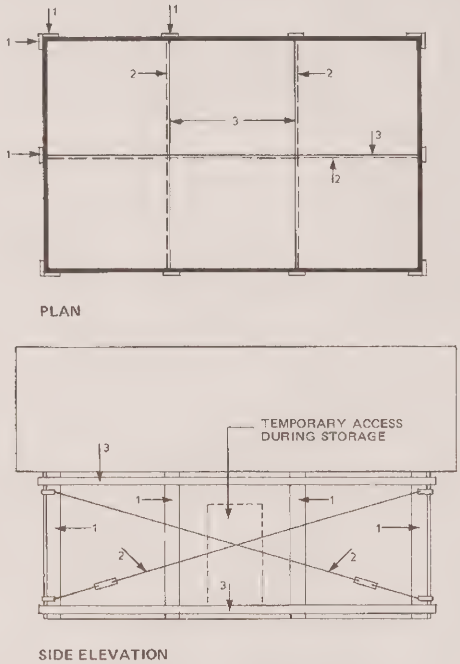
6.6 MOVING THE BUILDING: BEAM AND DOLLY METHODS

a. Fasten the dolly beams to lifting beams with chains.
b. Use a pulling vehicle fastened to the dolly beam to move the building with a second vehicle fastened behind to provide braking.

7.0 RELOCATION AND LOWERING OF THE BUILDING

a. Repair the existing or construct the new foundation as required; part foundation only if beam and dolly or flatbead trailers are being used to move the building.
b. Use the reverse of the process described in 6.5 to locate the building where required.
c. Use jacks, stringers and needle beams to lower the building onto the foundations. Openings left for the needle-beams can be filled in later.
d. If the new foundation has a platform surface roll the building onto the surface directly off the track beams.
e. The last 3 m (height of the jack) of lowering may have to be done from temporary hard points installed to the temporary framing or the building fabric for the purpose.
f. Carry out necessary repairs to sills, wall framing, etc.

8.0 ILLUSTRATIONS



LEGEND:

1- SIDE AND CORNER TIMBER WALING

2- TENSION CABLES WITH TURNBUCKLE

3- TEMPORARY BRACING

LEGEND:

1- SIDE AND CORNER TIMBER WALING

2- TENSION CABLES WITH TURNBUCKLE

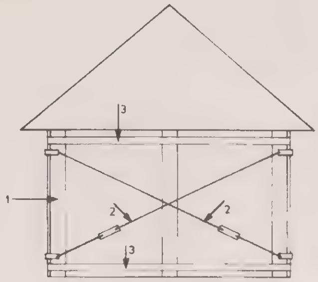
3- CONTINUOUS STEEL 'L' AROUND PERIMETER OF BUILDING AS REQUIRED

NOTE

AN ALTERNATE BRACING SYSTEM IS SHOWN IN STANDARD DRAWING SERIES, BRACING AND SHORING AOR0600 & AOR0601

PREPARATION FOR MOVING

TITLE / TITRE MOVING AND RELOCATING WOOD STRUCTURES 1 OF 3			SCALE / ECHELLE N.T.S.
Parks Canada Parcs Canada	SOURCE / RESOURCE REST. SERV.	CHECKED BY / VERIFIE PAR C.R.A	DATE / DATE 79.09.21
	DRAWN BY / DESSINE PAR JAN SKLENAR	REFERENCE No. / No. DE REFERENCE AOR0700A1	



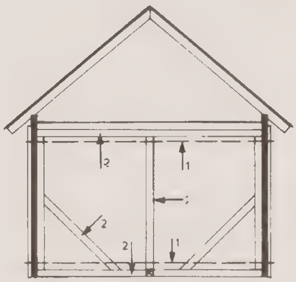
END ELEVATION

LEGEND:

1- SIDE AND CORNER TIMBER WALING

2- TENSION CABLES WITH TURN BUCKLE

3- CONTINUOUS STEEL 'L' AROUND PERIMETER OF BUILDING AS REQUIRED



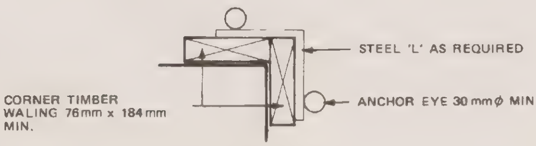
CROSS SECTION

LEGEND:

1- TENSION CABLES WITH TURNBUCKLE

2- TEMPORARY BRACING

3- BRACING, CABLES AND ALL TEMPORARY ATTACHMENTS MUST BE PLACED TO PROTECT HISTORIC FABRIC FROM ALL DAMAGE OR MODIFICATION



CORNER BRACE DETAIL

PREPARATION FOR MOVING

TITLE / TITRE			SCALE/ECHELLE
MOVING AND RELOCATING WOOD STRUCTURES 2 OF 3			N.T.S.
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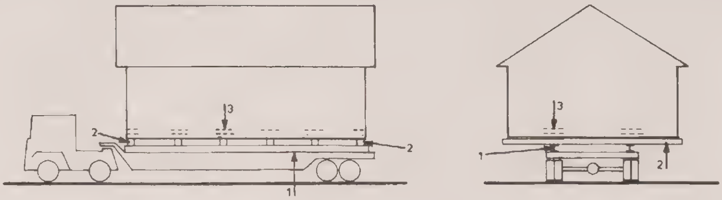


SIDE ELEVATION

END ELEVATION

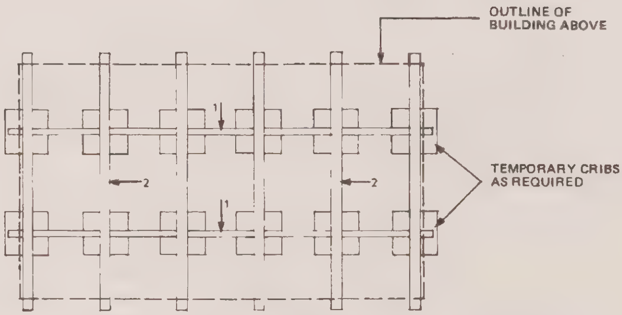
LEGEND:

1- MAIN BEAMS

2- SECONDARY BEAMS

3- BLOCKING TO SOLID BEARING AS REQUIRED

CARRYING BEAMS FOR TRANSPORT



PLAN

LEGEND:

1- MAIN BEAMS

2- SECONDARY BEAMS

TEMPORARY FOUNDATION

TITLE / TITRE			SCALE / ECHELLE
MOVING AND RELOCATING WOOD STRUCTURES 3 OF 3			N.T.S.
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9.0 BIBLIOGRAPHY

Very few references have been located that describe, in detail, the process of preparing and moving a building. However, the titles in this Bibliography each contain useful information or at least an informative perspective on the subject.

Curtis, J.O. 1979. *Moving Historic Buildings.* U.S. Department of the Interior, Heritage Conservation and Recreation Service, Washington, DC.

Mr. Curtis' book is an essential reference for anyone undertaking building moving. While it is strong on pre-move planning and preparation it is weaker on the technical process of lifting, relocating and setting a building down again. Contains a good section on preparation of the building and a useful case study. Probably oriented to the use of contractors instead of the "do-it-yourselfer."

A two-page bibliography contains many historic and contemporary articles on "house moving" which despite their interest are weak on the technical details. These items have been reviewed and the more useful ones included here. Illustrated.

LaPlant, E.W. 1916. "Modern House Moving Methods for the Carpenter and Builder," *American Carpenter and Builder* (April), pp. 75-76.

Contains several useful tips on raising and moving brick residences. Illustrated.

Madden, J. 1963. "Moving 3500 Tons of Building," *Architectural Forum* (July), pp. 108-9.

A brief article decribing the moving of a large reinforced concerete structure 100 metres across its site using rollers on concrete tracks. The photographs provide the best information.

Pryke, J.F.S. 1967. "Moving Structures," *The Consulting Engineer* (September), pp. 85-89.

A full description of the procedures used in moving two 1000 m^3 oil storage tanks using the hover-craft principle and the upper floors of a medieval timber frame building in a confined urban space using long hydraulic jacks. Illustrated.

Scientific American. 1903. "A Vertical House Moving." (December), p. 446.

Description of the lifting of a large residence 50 m to the summit of an adjacent bluff. Describes the basic steps and equipment used only.

__________. 1907. "Moving the Montauk Theatre." (September), p. 171.

Describes the moving of a massive brick theatre building. Some details of preparatory bracing and the turning of the building through 90° are included. Illustrated.

__________. 1923. "Moving a Church of 3200 Tons." (March).

A fairly complete description of the procedures for a short-distance move of a large masonry building using rollers on tracks. Illustrated.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

Canada

ARCHITECTURAL CONSERVATION TECHNOLOGY

VOLUME V

CONSERVATION MAINTENANCE

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
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PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA

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NOTE: Since this manual was in production when federal goverment departments were restructured in 1993, it was impossible to update all in-text government references. The Canadian Parks Services (CPS) of Environment Canada is now Parks Canada of the Department of Canadian Heritage, and Public Works is now part of the Department of Government Services.

Included within the seven volumes of the ACT manual is both basic and specialized information on architecture, engineering and landscape works.

References at all levels within these disciplines, useful both in practice and in training, are intended to:

- introduce and familiarize the user with conservation concerns;
- serve as an "aide-mémoire" at both the design and managerial levels; and
- provide guidance to professional consultants responsible for recording and analysing historic structures, and applying recommended conservation methods to their protection and preservation.

All procedures outlined in these publications should be read in conjunction with the reference material, manufacturer's literature and the relevant Canadian Parks Service – National Historic Sites Management Directives.

In all matters where detailed specifications are required, such as building codes, fire regulations and the use of chemicals, the prevailing and local references and regulations must be consulted and applied.

Please note that the ACT manual has been prepared within the context of Parks Canada Policy (1979). The newly proposed Canadian Parks Service Policy (1990) establishes additional and broader directions that, however, do not alter the orientation of the technical material covered. The ACT manual reflects the well established principles of conservation as defined by national and international charters and conventions – see Vol. I Appendix.

Within the proposed policy, the Cultural Resource Management (CRM) section (see Vol. I, Appendix 5.17) establishes the overall framework for the conservation and presentation of the cultural assets administered by CPS, on all CPS properties, including those in National Historic Sites, Historic Canals, National Parks, National Marine Parks, and other CPS properties. In the event of a conflict between the direction provided by the ACT manual and that provided by CRM Policy, the latter applies.

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VOLUME V
CONSERVATION MAINTENANCE

1
PREPARATION OF MAINTENANCE MANUALS

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ORIGINAL DRAFT: J. SMITH & B. JOHNSON

CONTENTS

1.0 INTRODUCTION

This article advances a standard content and format to be used in the preparation of individual maintenance manuals for historic sites and structures. It applies to all departmental staff involved in the writing and co-ordinating of maintenance procedures for historic sites.

2.0 GENERAL

2.1 MAINTENANCE MANAGEMENT

Historic sites and structures have complex operating and maintenance requirements from the moment of acquisition. Their preservation over the long term depends on a careful analysis of those requirements and the design of appropriate maintenance routines.

The purpose of a maintenance manual is to gather together the information needed to implement and co-ordinate such a program. The Department's overall Maintenance Management System defines basic maintenance functions, service levels and production standards applicable to historic assets. Technical and procedural content must be tailored to the individual site or structure and its phase in the development cycle.

The need for site-specific maintenance manuals is equally pressing whether the historic site or structure is in a pre-development or post-development phase. These manuals should be prepared by a team of persons involved with the site management and development.

2.2 PRE-DEVELOPMENT MAINTENANCE

Initial maintenance procedures are required even if a site is undeveloped. A pre-development maintenance manual should be prepared immediately after acquisition, to guide interim maintenance activity while long-term preservation and modification plans are being established.

The preparation of such a manual requires initial site inspections within the context of the Departmental Assets Inventory System to establish a list of site resources; to evaluate the physical condition of each component; and to identify categories and causes of deterioration. Preventive maintenance routines are then established in conjunction with any required interim stabilization designs.

2.3 POST-DEVELOPMENT MAINTENANCE

As a site is developed and opened for use, a revised maintenance manual is prepared, based on new and more detailed information gathered during the property research phase and co-ordinated with the conservation design drawings and specifications. This manual should contain enough detail and supporting documentation to allow smooth and self-sufficient maintenance management on site.

2.4 PROCEDURE/SCHEDULE FOR PREPARING MANUALS

It is most cost-effective to start the preparation of the Technical Maintenance Manual during the development of an asset. A dossier should be opened to include all the information required in Sections 1 and 3 of the manual as described below. Section 2 can be prepared from the National Master Specification and other available specifications. Updating of the manual should be done on an as required basis by the regional, headquarters or site staff. An annual review should also be done by site staff.

2.5 COPIES OF MANUALS

The original word-processing versions (both hardcopy and electronic storage), negatives of photographs and original drawings should be kept and appropriately stored at the regional or site office. Copies should be held at headquarters, the regional office and at the park/site.

Stone Gables, Kingston, ON

3.0 A FORMAT FOR TECHNICAL MAINTENANCE MANUALS

The same basic format, as outlined below, should be used for both pre-development and post-development phases of site maintenance programming. The availability of more extensive documentation will make the coverage in each category more extensive in the post-development phase. In any case more detailed housekeeping and seasonal maintenance routines are normally required to reflect the higher standards expected of sites in full public use.

On some sites containing a number of individual structures, a single pre-development manual for the whole site may be sufficient. As each structure is developed and opened for use, a separate post-development manual for that structure should be prepared.

The following sections comprise the basic manual format:

Section 1: Background for Maintenance:

- development history
- maintenance objectives (unique to site or asset)
- site plan
- inventory
- drawings, photographs or narrative showing original and replacement material

Section 2: Maintenance Specifications:

- inspection
- 100 Roads & Walks
- 200 Grounds
- 300 Cleaning
- 400 Infrastructure
- 500 Buildings
- 600 Capital Works
- 700 Marine Works

Section 3: References:
- list of resource persons by function specialty
- list of suppliers, products and contractors
- list of drawings (as built and as found)
- restoration contracts
- restoration specifications
- location of operating manuals
- sample requisitions

4.0 SECTION 1: BACKGROUND FOR MAINTENANCE

The first section of the manual should give the basic physical characteristics of the site or structure as a context for the other sections. Pertinent categories of information include:

a. a capsule history of the site or structure and its development, particularly recent alterations or modifications (i.e. property evolution);
b. a statement of the maintenance objectives unique to this site or asset with reference to the site's Master Plan if it exists, including appearance statement when available;
c. site plans; plans of individual garden and landscape areas; plans and elevations of buildings and engineering works if practical;
d. a summary of physical dimensions and area calculations for the overall site and for individual components where applicable, a copy of the Maintenance Management System (MMS) or Asset Inventory Data Base (AIDB) inventory sheets;
e. a set of as-built or as-found drawings, if practical, or photographs or a statement of what is original material; and
f. a copy of the MMS function list without descriptions (optional).

5.0 SECTION 2: MAINTENANCE SPECIFICATIONS

The MMS provides information for the management of assets. The specifications complement the MMS by providing technical information oriented to the needs of specific assets and follow the MMS breakdown to be as complementary as possible. The specifications can be written in the National Masters Specification format to facilitate use as contract documents or on the format sheets included under Section 7.0 General Format.

5.1 INSPECTIONS

The Asset Management Information System should capture all major work required on an asset. A site-specific inspection can be established to permit a continuous record of asset condition and highlight areas of concern.

5.2 FUNCTIONS 100-199: ROADS & WALKS

These specifications follow the MMS listing specifying the technical requirements for the maintenance of both contemporary and period roads, walks and related structures. Differences between the maintenance of original, contemporary or replacement materials should be clearly stated. Special attention may be given to winter maintenance, particularly the use of salts.

5.3 FUNCTION 200: GROUNDS

These specifications follow the MMS listing with a clear differentiation between period and contemporary grounds. The roles of interpretation officers and general works staff should be clearly stated. Period equipment should be specified and its use described. Special attention is required for the level of service. Scheduling should also be defined.

Ground Maintenance Equipment

5.4 FUNCTIONS 300-325: CLEANING

These specifications should clearly relate to the MMS function list but should also detail the areas of work. Three types of cleaning are envisaged:

a. contemporary cleaning of contemporary buildings – function 300/310;
b. contemporary cleaning of period buildings – function 301 – concerns the general areas of a period building; and
c. period cleaning of period buildings – functions 301/302 – concerns the special or display areas of a period building and may not be done by general works staff.

5.5 FUNCTIONS 325-499: INFRASTRUCTURE

These specifications relate only to the maintenance of contemporary services to a park and as such are not detailed in the Technical Maintenance Manual unless they affect period assets.

5.6 FUNCTIONS 500-599: BUILDINGS

These specifications cover both the contemporary and period functions of MMS. In certain instances contemporary functions can apply to replacement or replicated components of period assets. Those specifications should contain site specific formulae and products, especially paint and hardware schedules. Any original material should be highlighted by reference to the plans or related designs.

5.7 OTHER MMS FUNCTIONS

These specifications should be provided whenever special tasks are needed involving period assets.

6.0 SECTION 3: REFERENCES

This section provides links to other resources of use for maintaining the asset. They could be:

a. a list by MMS function, with names, titles, phone numbers and addresses of site personnel, resource personnel (past and present project team members) and other district, regional or headquarters staff as appropriate;
b. a list of suppliers and contractors, their addresses, brochures and product lists;
c. a list, with location, of relevant reports, record drawings and photographs and other technical documents;
d. a copy of all restoration contracts pertaining to this asset or a reference to the location of such documents;
e. a copy of all restoration specifications pertaining to any restoration contracts for this asset;
f. the location of all operating manuals on special equipment; and
g. sample requisitions and other forms.

7.0 GENERAL FORMAT

Although each site will have different requirements, there are common needs which determine a common format. These needs can be met by the use of:

- standard letter size paper
- three-ring binders
- a spine marking
- photo-holders

The use of these format items will greatly facilitate common acceptance. Technical Maintenance Manuals should use S.I. units of measurement; however, Imperial or old French units may be added where necessary to aid interpretation.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME V

CONSERVATION MAINTENANCE

2.1

MAINTENANCE PROCEDURES

HOUSEKEEPING PROGRAMS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: J. SMITH & B. JOHNSON

CONTENTS

1.0 INTRODUCTION

A housekeeping program is a predetermined set of maintenance routines performed by site personnel on a year-round basis. Included are the daily tasks performed during the visitor season and the pre- and post-season tasks required to provide continuous operation of historic grounds and structures. Such programs ensure that these physical resources maintain their intended historic character and appearance, avoid deterioration and decay and provide for public safety and security.

Inverarden, Cornwall, ON

1.1 PURPOSE

The purpose of this article is to compile the basic requirements of a housekeeping program for use by those responsible for the maintenance of historic buildings, structures, landscapes and gardens.

Note: For instructions on how the housekeeping program fits into the overall maintenance operation on historic sites, see Section 1 "Preparation of Maintenance Manuals."

2.0 ORGANIZATION

2.1 PLANNING AND DIRECTION

A housekeeping program must be tailored to the specific requirements of the particular historic site. To do this, it is necessary to have a management plan outlining short and long-term objectives for the site's operation and interpretation. This plan becomes the basis for a housekeeping program which specifically itemizes each component to be maintained, the method to be used, the resources required and the frequency of treatment.

The preparation of such a program requires a detailed inventory of site assets and a knowledge of what is required to ensure their continuing function as historically intended. Only with this background of historic practices and use of materials and staff can a proper program be planned, directed and carried out successfully.

On some sites, the intent is to include interpretation as part of the housekeeping operation, i.e. to carry on operations during periods of visitor use to show how the work was performed historically. In such cases, the program will require that operations be based on research into methods, workers and materials used during the historic period. Period tools and implements and the training of staff in their use may be required.

2.2 STAFF SELECTION AND RESPONSIBILITIES

Select personnel according to the level of difficulty of the task and the need for unusual or specialized skills. The irreplaceable and often fragile nature of many historic resources may demand special attention to manual dexterity and reliability.

Much of the responsibility for successful maintenance programming rests with the supervisor. A good supervisor should be familiar with the proper techniques for each task assigned and insist on properly trained personnel. Make sure there is an adequate supply of equipment and materials.

The supervisor should inform housekeeping personnel of the purpose of the various tasks as well as the techniques to be used. It is a supervisory challenge to keep housekeeping personnel from performing tasks for which they are not qualified.

ACME Tool Chest
1902 Edition of the Sears, Roebuck Catalogue

2.3 TOOLS, EQUIPMENT AND MATERIALS FOR STRUCTURES

Using the proper equipment for each job makes the task easier and less damaging to the historic resources. Purchase these during program establishment to ensure the right tools are available when needed.

A list of frequently used equipment with recommendations concerning applications and cautions is contained in Appendix 1, Section A.

2.3.1 Cleaning Materials

Proper selection of cleaning materials depends on maintenance priorities. They vary with the occupancy and the use of a structure. To achieve high levels of presentability in a heavily used contemporary environment, the use of strong chemicals is justified. However, use of similar chemicals is not acceptable in structures where the main objective is preservation of historic materials.

Any cleaning material intended to be used on historic materials must be tested first. Personnel must also realize that the preservation of materials is more important than convenience.

A list of cleaning and lubricating materials with comments on their proper use is contained in Appendix 2.

2.4 TOOLS, EQUIPMENT AND MATERIALS FOR GROUNDS

Grounds maintenance requires a variety of appropriate tools and equipment. Some are common and in frequent use in most areas, while others are site specific.

Grounds maintenance materials are also varied. Many are used to promote the continued healthy growth of the vegetation. As with other materials, ensure that tested and proven materials are selected and applied with care and at proper times. In grounds maintenance, it must be realized that preservation is the prime consideration and takes precedence over speed and convenience.

2.5 ASSISTANCE FROM OTHER SERVICE GROUPS

Some tasks of daily maintenance such as repairs to plumbing, heating and electrical systems or the care of specific artifacts have to be conducted by specialists other than the regular housekeeping staff. These may be recruited from within the CPS or under contract with outside institutions.

3.0 PLANNED ACTIVITIES

All procedures for a particular site must take into account the nature of its historic structures and materials and the objectives of the site's interpretive program.

For details of procedures and suggested frequencies of application, see Appendix 3.

3.1 EXTERIORS

3.1.1 Roofs, Flashings, Eaves and Downspouts:

Most maintenance of these elements is done on a seasonal basis. Nevertheless, carry out visual checks during all inspections and after thunderstorms, windstorms and other unusual conditions.

3.1.2 Gutters:

When clogged with leaves and other debris, gutters overflow and saturate surrounding members. To prevent overflowing, check gutters and clean them if necessary at least once a week from the first killing frost until the trees are bare and monthly thereafter until March.

3.1.3 Walls:

Rain carries particles in suspension. It can also splash dirt onto foundations and walls from ground surfaces or lower roofs. The force of a hose may drive this material off; if not, detergent and warm water should be adequate to loosen the dirt so that it can be rinsed away with a hose. Avoid strong soap solutions as they can damage wood finishes and masonry.

3.2 INTERIORS

3.2.1 Floors:

Treat floors with respect to their finish materials. Treatment specifics are described in Appendix 3, Section A. Treatment frequencies depend on type of occupancy, visitor traffic, type of environment and season of the year.

3.2.2 Walls, Ceilings and Trim:

Use dry and wet methods of cleaning as described in Appendix 3, Section A. Treatment frequency depends on the type of environment and use of the space.

3.2.3 Decorative Features:

Decorative features are made from a wide variety of materials. To determine an appropriate treatment and a frequence of treatment, it is advisable to consult a conservator.

For more information, see Appendix 3, Section A.

3.2.4 Metal Surfaces:

To prevent gradual erosion of metal with each polishing treatment, consider protective coatings such as lacquers, microcrystalline waxes or paste waxes. The use of these materials should be approved by a conservator.

To protect adjacent materials from polishes, use cardboard templates.

When cleaning a stove, cover all furnishings, dismantle pipes and do as much cleaning as possible outdoors.

For additional information, see Appendix 3, Section A.

3.2.5 Hardware:

The most frequently used hardware in historic structures and grounds are latches, locks and hinges. When worn through use, they can either be repaired or replaced. In general, repairs are more desirable because they allow retention of the original materials. No replacement should be done without approval of a project team or regional conservation staff.

Latches, particularly their moving parts, often wear out. Remove for major cleaning, checking rivets and pivots for wear. If the screw and nail holes are enlarged, repair by plugging.

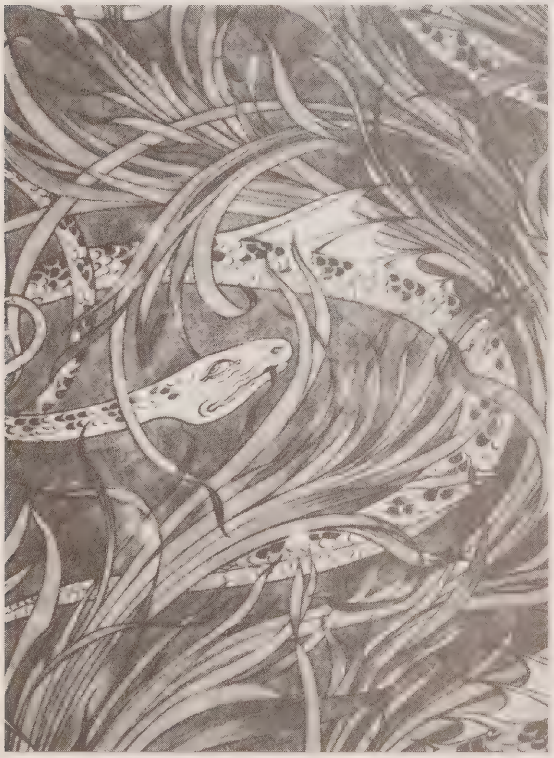
The usual maintenance problem with locks is a loose knob on one end of the spindle. Repeated pulling and turning of the knob results in wear to the set screw hole. It is helpful to reverse the spindle and the knobs from time to time to even out the wear. When the hole gets too big, a more permanent repair must be made.

Hinge problems usually arise from either wear at the knuckles or loosening of the screws. Worn hinge knuckles can be built up with new material or can have small washers placed between the knuckles to return the door or window to its original height. Repair loose screws using standard techniques for enlarged holes.

3.2.6 Papers and Fabrics:

Historic fabrics and paper wall coverings are so fragile that no cleaning treatment is safe to use unless approved by a conservator.

Protection from human erosion is the best treatment for historic or historically accurate fabrics and paper.



Historic wallpaper design

3.2.7 Venetian Blinds:

Dust blinds by lowering them full length and turning the slats to a closed position. Dust the entire surface with a treated dust mop or vacuum cleaner, rotate the slats to the other side and repeat the process. Then, open the slats and brush dust out of the tapes.

3.2.8 Window and Door Openings:

Maintain window sashes and door frames with respect to the materials they are made of. See Appendices 1 to 3.

Hardware and metal parts should be maintained as described in Appendices 1 to 3.

Glass in doors and windows should be cleaned using procedures and detergents as indicated in Appendix 3, Section A.

3.2.9 Foundations:

During regular inspections, look for interior deterioration or visible defects to the foundations. Since the scale of repair work is usually beyond the range of normal housekeeping, report the findings to a supervisor to arrange a proper method of treatment.

3.2.10 Attics and Crawl Spaces:

Attics and crawl spaces are not usually accessible to the public. They should be cleaned and maintained on a seasonal basis.

It is a good practice to check these spaces for possible signs of damage after heavy rains, windstorms or similar unusual circumstances.

3.3 MECHANICAL AND ELECTRICAL EQUIPMENT:

a. Heating:
   During the heating season, check the safety valve and boiler thermometer regularly.

   Check the flue connection from the boiler to the stack for defects and paint with heat-resistant paint when necessary.

   Inspect the bottoms of radiators for water, which may be an indication of leaks or faulty joints.

Clean filters and grilles of hot air systems monthly or bimonthly if dirt accumulations are substantial.

Fuel Lines are difficult to inspect because they are most often concealed. If possible, check for signs of deterioration.

b. Electrical Systems:
Specialists must maintain electrical systems. Housekeeping personnel may replace burned or broken bulbs and clean lights and fixtures.

c. Security System:
If the security system has a trouble light, it should be tested daily. If it includes internal testing features, these should be activated daily to detect inside tampering.

3.4 GROUNDS

3.4.1 Lawns and Grassed Areas:

These are treated with respect to the species of grass grown, historic and contemporary function, frequency and type of use, location and seasonal and climatic conditions.

Some areas are highly maintained for appearance, such as in display gardens, while others are maintained to a lesser degree such as meadows or fields around fortifications which should resemble historic conditions. Use extreme care in maintaining healthy growing conditions through careful and timely maintenance practices.

3.4.2 Trees and Shrubs:

Treatment of trees and shrubs depends on the species involved, their growth habits, climatic conditions, their use or purpose in a given grounds development and their location within the historic site.

Where they form a part of the natural historic setting there is little or no maintenance involved as they are allowed to grow to natural maturity. However, where they have been planted as specimens, hedges or in orchards, maintenance practices will be governed by and according to the specific site requirements. Specific treatments are described in Appendix 3, Section B.

3.4.3 Planting Beds:

The treatment of shrubs, annuals and perennials planted in clearly delineated planting areas varies with the species and types of plants, climatic conditions, seasonal changes and intended purpose of a particular planted area.

Very formalized plantings require more frequent and precise maintenance. Annual planting beds require yearly seasonal plant replacement with the same species, whereas perennial plantings need only seasonal care with occasional replacement of dead or damaged plants.

3.4.4 Ground Covers:

Areas planted with ground cover require little care other than occasional trimming or cutting back of growth or replacement of dead or diseased material. Maintenance practices will vary according to species involved, location and purpose of the planting, climatic and seasonal conditions.

3.4.5 Vegetable Gardens and Cropped Areas:

These areas require frequent attention during the growing season, again depending on the type of plants or crops involved, the climatic conditions and their role within a particular site.

Garden or cropped areas in historic sites are usually developed to re-establish areas to historic use patterns; therefore, maintain either as areas for interpretation using methods and materials based on historic practices or use contemporary or mixed maintenance practices where interpretation is not a key factor.

3.4.6 Constructed Elements and Furnishings:

Examples of constructed elements in the landscaped areas of sites are fences, walls, shelters and pools. Furnishings include statues, swings, benches, seats, flagpoles and lights.

These require varying degrees of maintenance depending on the type of element, the materials used and their exposure to varying use and climatic conditions. Among the procedures necessary are regular cleaning, stabilization and minor repairs to ensure safety. Proper selection of cleaning materials and use of compatible repair materials are important in maintaining these elements.

3.4.7 Surfaced Areas:

These are ground areas other than grassed or planted areas which have been stabilized in some form primarily for circulation or as rest or other public use areas. Included are walks, drives, paths, patios, yards, copings, edgings, parade grounds, embankments and other areas covered with stabilized earth, stone, gravel, boards, etc., providing a firm footing or to contain an area in an overall grounds development.

Normally maintenance requirements are minimal and consist of keeping areas clean and well-drained, making minor periodic repairs and stabilizing or replacing eroded materials.

3.4.8 Miscellaneous Areas:

These are areas such as embankments or mounds, foundations or areas set aside as important for possible future study or development based on studies either planned or in progress. As such, maintenance consists mainly of protection and preservation to ensure they are undisturbed until proper research can be carried out to determine future action.

4.0 RECORDS AND SCHEDULES

4.1 WORK RECORDS

The housekeeping supervisor's work records should include an up-to-date housekeeping manual with the changes approved by resource people or management. They should include a time budget, a materials budget and a materials and equipment inventory showing the stock on hand and sources of material. They should outline the daily cleaning routines and job procedures and the cleaning schedules by area and job. Records should include the building cleaning schedule, the log of housekeeping work done and to be completed and notes on any new material being tested.

4.2 SCHEDULE OF OPERATIONS

The planning and scheduling of housekeeping activities will be done within the framework of CPS's overall Maintenance Management System. Special consideration in the planning for historic sites must be given to the need for co-ordination with interpretive programs and with consultations between maintenance staff and conservation specialists as special situations arise.

Vegetable gardens, St. Andrew's Rectory, Selkirk, MB

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

5.0 APPENDIX 1: TOOLS AND EQUIPMENT
SECTION A – HISTORIC STRUCTURES

	EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
1.	Vacuum cleaners	• Dust removal from hard surfaces • Cleaning of contemporary carpets	• Avoid automatic cord reels	• Canister type preferable
2.	Carpet sweepers	• Cleaning of low-pile carpets		• Useful for high traffic areas
3.	Floor polishers	• Waxing - operations	• Danger of abrasion: not to be used on or near exposed historic wood surfaces	
4.	Step ladders	• Access to curtain fastenings, upper walls, ceilings	• Ensure built-in protection against ceilings	• Wood ladders more difficult to maintain but more compatible with most historic environments; alternatives are metal, fibreglass
5.	Extension ladders	• Access to external walls, eaves, roofs	• Ensure built-in protection against wall damage; metal ladders are dangerous with power tools and overhead lines	• Wood ladders more difficult to maintain but more compatible with most historic environments; two ladders required for ladder jacks and plank arrangement
6.	Wet mops	• Floor cleaning and rinsing		• Commercial quality cotton yarn; separate mops for cleaning, rinsing
7.	Sponges	• Dirt removal from hard surfaces		• Cellulose tougher, polyurethane softer
8.	Chamois	• Dirt and dust removal from windows, hard surfaces		
9.	Squeegees	• Water removal from hard, flat surfaces	• Ensure proper sizes to avoid perimeter damage	

5.0 APPENDIX 1: TOOLS AND EQUIPMENT

SECTION A – HISTORIC STRUCTURES

	EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
10.	Pails	• Water supply	• With metal pails, more risk of marring furniture and trim; metal pails to be avoided for marble surfaces	• Metal pails harder to maintain and clean but more compatible with historic environments; alternatives: polyethylene
11.	Gloves:			
	• cotton	• Protection for historic materials from oils in skin		
	• rubber, plastic	• Protection for skin from cleaning materials		
12.	Brooms:			
	• long handled	• Dirt removal from hard surfaces	• Limit to exterior use	• Hard bristles for surface walks and drives; soft bristles for painted exterior surfaces; separate brooms for interior and exterior use
	• short handled (whisks)	• Dirt removal from corners, crevices		
13.	Scrub brushes	• Dirt and dust removal		• Tapered for corners, stairs; long-handled for hard floor surfaces
14.	Dust mops/cloths	• Dust removal from hard surfaces	• Avoid treated mops and cloths on porous materials (exposed wood, marble) and glass	• Dust cloths about 1 m^2 non-ravelling edges
15.	Hand tools:	• Variable		

Measuring	*Holding*	*Cutting*	*Installing*	*Other*
Tape/folding rule	Pliers	Saws	Screwdrivers	Flashlight
Square	Clamps	Knives	Trowel	Safety light
Level	Vise	Shears	Putty knives	Funnel
	Brace/drill set	Hammers/nail set	Crowbars	
	Chisels	Brushes	Shovel	
	Files			
	Planes			
	Scrapers			
	Sandpaper			
	Steel wool			

5.0 APPENDIX 1: TOOLS AND EQUIPMENT
SECTION B – GROUNDS

EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
1. Lawn Mowers	• Cutting grass		
• hand		• Ensure blades are well sharpened and in proper height adjustment; avoid obstacles	• Preferable for historic accuracy
• power		• Electric or gasoline operated, requires an understanding and caution in use; ensure that proper maintenance and safety precautions are followed	• Do not use where historic accuracy required – reel type is preferable; use smallest equipment which will do a reasonable job based on size of area to mow
		• For attachments used with tractors or small powered riding machines, employ trained operators	• Mainly suitable for cutting large areas where a rougher and higher cut is required
		• Safety precautions to be followed	
2. Snow blowers	• Removing snow	• Requires care in operation	• For areas used by visitors in winter or for heavy snow areas
		• Can damage surfaces	• Use only on larger areas
		• Use smaller types only	• Hand shovelling is preferred in historic environment
3. Spreaders	• Spreading fertilizers or grass seed	• Clean after using fertilizers; calibrate accurately for proper distribution of seed or fertilizer	• Small manual types are recommended for general use

5.0 APPENDIX 1: TOOLS AND EQUIPMENT
SECTION B – GROUNDS

EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
4. Cultivators	• Breaking up ground, loosening soil	• Requires experience in operating; power models are noisy in operation	• Use small powered types for garden areas or manual ones for historic accuracy
5. Speed drills	• Opens soil, plants and covers seeds		• Used for planting garden or field crops
6. Rollers	• Levelling and compacting lawn areas or other surfaced areas		• Use water or sand filled types, hand-drawn preferred
7. Edgers	• Trimming grass along edges of paths, walks, planting beds		• Available as electrical or gas-operated, cord or blade type; manual or small electric types preferred
8. Sprinklers	• Watering lawns and flower or shrub beds		• Various sizes and types available: oscillating or revolving, fixed and travelling • Small fixed (moveable) types preferred (oscillating or revolving)
9. Hoses	• Watering • Distributing water		• Available in plastic or rubber in varying sizes; rubber types more durable and older type in use
10. Wheelbarrows	• Moving of materials, soil, waste, etc.		• Modern versions are all steel; select heavy duty types (wood frames) as used in the past
11. Extension Ladders	• Pruning trees, hedges, picking fruit, reaching high structures		• Straight type or stepladder type that unfolds • New models are aluminium • Wood heavier but more authentic in historic environment

5.0 APPENDIX 1: TOOLS AND EQUIPMENT
SECTION B – GROUNDS

EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
12. Lawn sweepers	• Picking up leaves or grass cuttings		• Not an essential item where mowers pick up cuttings • Can be useful for picking up leaves instead of raking • Contemporary item • Non–powered
13. Blowers, vacuums		• Power operated; noisy, can suck up rock or debris	• Not essential though useful on large areas; usually gasoline–operated
14. Shredders, grinders	• Shredding of leaves, bark twigs – for disposal, mulching, or compost		
15. Pruning shears	• Pruning of branches, limbs of trees, shrubs, hedges		
16. Aerators • hoes (wheel type)	• Breaking up ground		
17. Hand tools			
• sickles, scythes, saws, edgers, shears, knives	• Cutting	• Tools must be kept sharp, free of rust and defects	• A variety of types and sizes will be required for each site • List is only indication of types possible
• dibbles, trowels, hoes, rakes, shovels, forks, weeders, cultivators	• Planting, digging	• Keep tools in good condition, free of rust and defects	• Kinds and quantities determined by specific site conditions
• dusters, sprayers	• Applying materials	• Use proper equipment to suit type of material used, spray of liquids, dust or powders	• Insecticides, pesticides to be used only where necessary and applied as per manufacturer's instructions
• sprinkler heads, sprinkler cans, brushes	• Watering small areas		

5.0 APPENDIX 1: TOOLS AND EQUIPMENT
SECTION B – GROUNDS

EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
• tapes, squares, levels	• Measuring and layout		• Used primarily for laying out vegetable gardens and crop areas
• measuring cups	• Measuring	• Avoid spilling and careless handling of chemicals	• Used for measuring chemicals
• brooms, rakes, brushes, snow shovels	• Cleaning and grooming	• Use care to avoid damage to edgings when using rakes or shovels	• Replace damaged or worn items immediately
• hammers, pliers, screwdrivers, wrenches, sharpening stones	• Repairs and maintenance of tools and equipment	• Keep tools in good condition and ensure proper types are available at all times	• Equipment will deteriorate or become useless without required maintenance

5.0 APPENDIX 2: CLEANING MATERIALS

	EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
1.	Soaps	• Chemical release of oily dirts	• Ensure use of neutral soaps without additives • Use only with soft water	
2.	Detergents	• Chemical release of dirts	• Ensure use of *non–ionic* detergents • Avoid any strongly alkaline or acidic cleaners	• Supplies may have to be arranged through chemical supply houses or conservation laboratories
3.	Abrasives	• Mechanical release of dirts	• Careful testing required to assess possible surface damage	
4.	Mineral spirits	• Chemical release of stubborn stains on painted surfaces	• Treated areas must be wiped dry immediately	
5.	Metal polishes	• Cleaning of brass and other metal surfaces	• Ensure use of good quality household-type products applied according to manufacturer's directions	• Recommended: "Never Dull" magic waxing polish for fine metal work; there are no abrasives to scratch surface
6.	Oils	• Lubrication of locks and other mechanisms		• Recommended: WD-40 grade for general use
7.	White petroleum jelly	• Lubrication of window bolts and other sliding members		• Apply thin coats to shafts, small amounts to guides and keepers
8.	Poultice of clay lime	• Cleaning of grease spots on wooden floors with no finish		
9.	Waxes	• Protects against material abrasion and wetting	• Do not use waxes which have to be removed with strippers	

5.0 APPENDIX 2: CLEANING MATERIALS

	EQUIPMENT	APPLICATION	CAUTIONS	COMMENTS
10.	Window washing solutions	• Cleaning of window glass		• Use soapless water with ammonia or a mixture of ethylene glycol monoethyl ether and non–ionic detergent, 3 g for each 4 L of water
11.	Lemon juice and salt	• Cleaning of yellowish stains on china		
12.	Hydrogen peroxide	• Cleaning of yellowish stains on china		• Use 15 percent concentration

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION A – HISTORIC STRUCTURES

Element/Section	Material	Treatment	Procedure[1]	Frequency[2]	Comments
FLOORS	1. Wood	a. Dry cleaning	• Treated mop, with brushes for crevices and corners, putty knife for sticky substances	A	
		b. Damp cleaning	• Dry clean first; use string mop wetted in soft water and wrung nearly dry • For stubborn dirt, damp mop with non-ionic detergent; rinse with damp mop, clear water; dry with almost-dry mop	B	• Move furniture and fabrics to avoid contact • Special care required around baseboards, other trim
		c. Waxing	• Clean the floor first; apply non-skid paste wax with a dampened, clean soft cloth; place a small amount of wax on the cloth and wipe it over the floor, leaving a thin and even coating • Polish the wax • After polishing, sweep the floor to pick up stray wax grains		• Paste wax is recommended for historic materials, because it can be reconditioned without stripping by applying more wax and rebuffing
	2. Linoleum/ cork/oil–cloth	a. Dry cleaning	• See 1.a.	A	
		b. Damp cleaning	• See 1.b.	B	
		c. Waxing	• See 1.c.		

1. Re: References in "Procedure" column – (i.e. See 1. a.):

   Number refers to "Material" column; *Letter* refers to "Treatment" column

2. "Frequencies" can only be suggested, not prescribed; they must be specified for each particular case:

   A – daily to weekly; B – weekly to monthly; C – intervals longer than one month.

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION A – HISTORIC STRUCTURES

Element/Section	Material	Treatment	Procedure [1]	Frequency [2]	Comments
	3. Marble	a. Dry cleaning	• Non-treated dust mop, brushes, putty knife	A	
		b. Damp cleaning	• See 1.b.	B	
		c. Wet mopping	• Wet floor with cleaning solution, mop twice to agitate cleanser; scrub corners with tapered brush; pick up solution with mop wrung dry; use second mop to rinse twice with clean water; pick up rinse water with second mop wrung dry	B	• Never use acidic cleaners on marble
	4. Other masonry	a. Dry cleaning	• Smooth surfaces; see 1.a.	A	
			• Rough surfaces: vacuum with brushing as required	A	
		b. Damp cleaning	• See 1.b.	B	
		c. Wet mopping	• See 3.c.	B	
	5. Fabric/ fibremats	a. Dry cleaning	• Contemporary materials: vacuum	A	
			• Historic materials: consult conservator		
WALLS/CEILING	6. Wood	a. Dry cleaning	• See 1.a.	B	
		b. Damp cleaning	• See 1.b.	B–C	
		c. Waxing	• See 1.c.	C	
		d. Other types of cleaning			• Method selected for other types of cleaning depends on type of wood finish

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION A – HISTORIC STRUCTURES

Element/Section	Material	Treatment	Procedure[1]	Frequency[2]	Comments
	7. Marble	a. Dry cleaning	• See 3.a.	B	
		b. Damp cleaning	• See 1.b.	C	
	8. Other masonry	a. Dry cleaning	• See 4.a.	B	
		b. Damp cleaning	• See 1.b.	C	
	9. Plaster work	a. Dry cleaning	• See 1.a.	B	
		b. For other cleaning, consult conservator		Prescribed by conservator	
	10. Wallpaper	a. Consult conservator		Prescribed by conservator	
WINDOW AND DOOR OPENINGS	11. Wooden parts	a. Cleaning	• See 1.a. and 1.b.	A–B	
	12. Glass	a. Cleaning	• Use mild solution of non-ionic detergent in lukewarm, soft water or a mild commercial cleaner containing ammonia; to dry windows with many small panes, it may be easier to use a chamois than a squeegee	B–C	• Do not use any abrasives for cleaning glass
	13. Damaged glass		• Replace as soon as possible		• Work is done by contractor, not by maintenance staff; for period glass, consult conservator

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION A – HISTORIC STRUCTURES

Element/Section		Material	Treatment	Procedure[1]	Frequency[2]	Comments
METALS	14.	Iron	a. Polishing	• Protective stove polishes containing graphite should be applied as recommended by manufacturer	A–B	
			b. Cleaning corroded areas	• Use 0000 steel wool and polish with 600 grit wool, then polish with 600 emery paper.	C	• Limit use of abrasives as much as possible
	15.	Brass	a. Polishing	• Use mild brass polish on soft cloth according to manufacturer's instructions	A	• "Never Dull" waxing polish or equivalent recommended for having a minimum chemical and physical effect on metal
			b. Protective coating	• Protective coating such as lacquer, paste wax or microcrystalline wax to be applied on clean polished surface with approval from conservator • If waxes are not available, apply a very thin layer of cooking oil to all brass parts except door knobs	B	• Use templates to protect adjacent materials from being waxed; use gloves when polishing brass
	16.	Other metals	a. Polishing	• Historic materials: consult conservator	Prescribed by conservator	
			b. Protection	• Contemporary materials: use manufacturer's instructions for cleaning agent		

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION A – HISTORIC STRUCTURES

Element/Section		Material	Treatment	Procedure[1]	Frequency[2]	Comments
HARDWARE	17.	Latches	a. Cleaning	• Dry clean first; for stubborn dirt, damp mop with non-ionic detergent; rinse with damp mop, clear water; dry	C	• Most of the care belongs to seasonal maintenance
	18.	Locks and hinges	a. Cleaning	• See 17.a. above		
			b. Oiling		C	• Belongs to seasonal maintenance

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
LAWN	1. Grass	a. Mowing	• Mow to a height of 15 mm unless otherwise indicated	A	• Frequency depends on climatic conditions, grass species and rate of growth; once weekly is normal during growing season
			• Allow clippings to accumulate unless build-up is excessive		
			• Alternate direction of cut at each mowing		
			• Do not remove more than 1/3 of growth at each cutting		
			• Mow meadows or large areas (now lawns) to a height of 200 mm	B–C	• Frequency as required to maintain height – two or three times a season or when fire danger exists
		b. Trimming	• Trim grass neatly around trees and along edges of flower and shrub beds and edges of walks, walls and curbs		• Normally done at each mowing period • Specific plans indicate areas where no trimming is to be done
		c. Watering	• Apply water as required during growing season to maintain healthy growth using portable sprinklers	B	• Frequency depends on seasonal rainfall conditions
			• Allow for a minimum 50 mm of soil moisture penetration		• Avoid frequent light waterings; evening or morning watering preferred

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
		d. Fertilizing	• Apply a slow release fertilizer of 50 percent organic content, according to formulation, amounts based on bi-annual soil tests; use small spreading equipment • Avoid overlaps and excess spreading at start and stop; water after fertilizing	C	• Normally fertilized twice a year in spring and fall; do not over-fertilize; milorganite is a preferred fertilizer for lawns; use fertilizers with weed killers only when absolutely necessary
		e. Weeding	• Remove scattered weeds by hand; in larger areas, apply weed killer using spray equipment for individual plants, or powders and spreaders	A	• Remove weeds by hand as they occur; use only approved chemicals when weeds become a problem and use with care
		f. Reseeding and sodding	• Rake and remove dead grass and debris • Loosen soil and add clean friable topsoil to proper level • Apply seed or sod to match existing grass type – roll lightly and water to maintain moisture (use light spray) and insure growth	C	• Done only when required to repair damaged areas or dead grass; use same sod or grass species, repair as damage occurs
		g. Aerating	• Use equipment that extracts and deposits earth plugs a minimum 60 mm deep and 120 mm o.c. • Drag mat over area to break up and spread plugs over grass area	C	• Done only when necessary due to evidence of soil compaction and damage to lawn grasses; done only when soil is dry

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
		h. Raking	• Rake and remove dead grass and debris in spring and debris in fall after all leaves have fallen	C	• Done in early spring prior to start of season and in fall prior to end of visitor season
			• Dispose of material by mulching or placing on compost piles		
		i. Cleanup	• Remove all paper, trash, debris, etc. from lawn or other grassed areas	A	• Done as material is discovered, normally on a daily basis in highly used areas
TREES AND SHRUBS	1. General	a. Pruning	• Prune only when necessary to maintain shape or natural character or to remove dead, diseased or unwanted growth	C	• Frequency depends on growth conditions, proper season for pruning or damage from storms or disease
			• Use clean sharp cutting tools (hand type)		• Follow accepted pruning practices for fruit trees (single or in orchards)
			• Make clean cuts close to trunk or larger branches and follow accepted pruning practices		
			• Paint large wounds with tree wound preservative paint		• Use renewal pruning methods whenever possible
	2. Deciduous		• Prune heavy bleeders (birch/maple) when in full leaf		
			• Prune hedges wider at bottom than at top		
			• Prune to retain shape and desired height		

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
			• Prune in season according to shrub types		• When in doubt, do not prune
			• For summer or fall blossoming, prune in winter or spring		• Consult reference material for proper practices
	3. Coniferous		• Prune in fall or spring before main growth takes place		
			• Prune evergreens carefully; do not cut main leader; prune to retain shape and size by pinching out or cutting candles		
		b. Watering	• Water trees and shrubs as required to maintain healthy growth	B	• Frequency is dependent on location and climatic conditions
			• Apply water slowly and deeply to allow for soil penetration of 100–150 mm		• Where normal rainfall is sufficient, little watering is required
			• Water evergreens deeply prior to onset of frost to prevent dessication and leaf browning during winter		
		c. Mulching	• Apply mulch to tree saucer areas and to shrub areas; apply 50–100 mm on deciduous material and 100–150 mm on evergreens using straw, leaves or other locally available material	C	• Woodchips, shredded bark or peat moss should not be used where historic accuracy is required
			• Apply mulch in fall		

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
			• After trees are established, remove saucers and omit mulch on single trees; mulching can continue where trees grow in groupings		
		d. Weeding	• Remove weeds from shrub plantings by hand digging or cultivating; restore cover	A	• Remove weeds as they occur during routine daily inspections
		e. Fertilizing	• Spread fertilizer by hand in shrub areas, using organic fertilizers wherever possible	B	• Normally carried out in early or late spring
			• Base formula and application rate on soil test results taken bi-annually		
			• Dry root feeding methods are preferred for trees	C	• Normally required between one to three years' frequency
			• Use appropriate types for evergreen or deciduous materials		
			• General requirement for trees is 1 to 3 kg of nitrogen per 9 m^2 or 1 to 2 kg of complete fertilizer 125 mm dia.		
		f. Spraying	• Spray only when required to control insects or disease using approved chemicals applied with hand spray equipment	C	• Follow horticulturally accepted sprays, techniques and time for fruit tree and orchard plantings

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
		g. Cleanup	• Ensure that all tree and shrub areas are clean and free of trash, paper, debris or foreign material	A–B	• Routinely done as material becomes evident
PLANTING BEDS	4. Plants Annuals Perennials	a. Planting	• Plant annuals and perennials from seedlings grown in flats, after ground has been lightly cultivated • Remove any plants which do not grow and thin seedlings as required • Follow historic planting plan using same plant species • Plant bulbs in fall at depth and spacing required for each bulb type	B	• Normally in spring, with bulbs planted in fall
		b. Watering	• Water all newly planted material immediately and prior to freeze-up in the fall • Water beds during season to provide moisture penetration of 100-150 mm and to ensure continued growth; use soft sprays to avoid washing away soil	B	• Frequency depends on local climatic conditions during growing season • Use hoses with sprinkler heads or watering cans for small areas
		c. Cultivating	• Cultivate soil to a minimum depth of 50 mm using hoes or other hand tools	B	

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
			• Cultivate in spring prior to planting and during season to loosen soil and assist moisture penetration		
		d. Fertilizing	• Add manure, compost to beds or a balanced organic fertilizer, ideally milorganite; work material lightly into soil after frost has gone or broadcast on surface	B	• Base application and formula on soil tests when commercial fertilizers are used
		e. Weeding	• Remove weeds as they occur using hoes or weed extractors or pull them out by hand • Place material on compost piles or dispose of with trash • Allow leaves of bulbous plants to ripen • Pinch off flower heads after they die	A–B	• Avoid use of chemical weed killers in planting bed areas
		f. Mulching	• Apply mulch material, straw, grass clippings, pine needles etc., to beds at 50-100 mm or 100-150 mm depth in spring • Apply additional mulch in fall over areas planted in bulbs or other tender plants; replace mulch after cultivating	C	• Normally carried out twice a year minimally, with material replaced during season
		g. Cleanup	• Remove dead plant material or flowers as they occur	A–B	• Check during other routine maintenance operations

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
GROUND COVERS	5. Plants	a. Planting	• After initial plantings are established, only dead or diseased plants will need replacement and this can be done by preparing rooted cuttings for replanting	C	
		b. Watering	• Water only as required to maintain vigorous growth • Water in mornings or evenings • Ensure water penetration is 100-150 mm	B	• Depends on local climatic conditions during season
		c. Weeding	• Remove weeds by hand as they appear • Once cover is well established weeds should be minimal	C	
		d. Fertilizing	• Apply fertilizer in early or late spring; use organic-type fertilizers (milorganite) • Ground covers require about 9 kg/1000 m^2 nitrogen	C	• Base requirements on soil tests – ground covers normally grow well with minimal fertilizer application
		e. Pruning	• Prune only when growth is too dense and material starts to crowd or infringe on other plantings, walks or edgings • Use hand cutting tools and trim lightly	C	

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION B – GROUNDS

Element/Section		Material	Treatment	Procedure	Frequency	Comments
			f. Cleanup	• Ensure that all ground cover areas are kept clean and free of all paper, trash and other foreign material	C	• Remove material as soon as it is obvious
VEGETABLE GARDEN	6.	Vegetable	a. Cultivating	• Dig up soil by means of forks, spades or tilling equipment to a depth of 200 mm and work soil to loosen it	C	• Done in fall prior to freezing or in spring
				• Add compost material, manure or fertilizer		
				• Rework soil and arrange ground in furrows for planting seeds and seedlings following historic layout for spacing and length of rows	A–C	• Done in spring after ground is dry and workable
				• Cultivate to 50 mm weekly during season		
			b. Planting	• Sow seed in spring after frost has left ground and it is dry and workable; sow according to directions for seed types; thin seedlings when they develop to allow for proper plant spacing	C	• Plant according to recommended sowing dates for specific plants in specific locations • Use same materials each season for historic authenticity
				• Set out plants grown from flats at proper intervals for growth		
			c. Fertilizing	• Use manure, compost, organic-inorganic mixed fertilizers applied according to soil test requirements	C	• Done in spring after ground is dry and workable • Do not use milorganite

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
			• Spread evenly over area to be planted and work into soil; use a balanced formula		• Average coverage 5-10-10 is 2 kg/10 m^2
		d. Watering	• Water garden area during growing season using hoses and sprinklers or sprays • Water deeply to allow moisture penetration • Water immediately after planting seeds or seedlings; water lightly	B	• Frequency depends on local seasonal climatic conditions; on average water every seven to ten days
		e. Pest control	• Remove minor insects by hand, otherwise use accepted insecticides applied in liquid or powder form; use insecticides only when insects become a problem	B	• Liquid sprays are better as they leave no visible residue and give better coverage
		f. Weeding	• Remove all weeds by hand using hoes or weed extractors as weeds occur, cultivate soil lightly while weeding, place material on compost piles	B	• Most weeding can be accomplished by hand • Do not use chemical sprays
		g. Harvesting, cleanup	• Remove any foreign matter such as paper, debris, etc., which may accumulate • Harvest vegetables as they ripen • Dig dead vegetation into soil or place on compost heap	B	• Normally done in late summer and fall

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
CROPPED AREAS	7. Field crops	a. Cultivating	• Plow ground in spring to a min. 150 mm depth to break up clods and level soil using a toothed harrow	C	• Annually after ground is dry and workable
			• After crops have been harvested, plow remains into soil		• Annually in the fall
		b. Fertilizing	• Work well-rotted manure into soil, at approximately 600 kg/ha or 10-6-4 fertilizer at 100 kg/ha	C	• Annually in the fall
		c. Planting	• Plant seed in spring by planting in rows using mechanical seed drills (or broadcast by hand)	C	• Plant after ground is dry and workable
			• Use same crops as originally planned or rotate according to historic practices		
		d. Weeding	• Remove weeds as they occur using hoes, rakes or other hand tools; where weeds are a problem, hand-spray equipment can be used	B	• Weekly to monthly weeding required • Use only approved chemical weed killers
			• Dispose of weeds on compost heaps		
		e. Harvesting	• Harvest ripened crops using mechanized harvesting equipment to cut crops	C	• Harvest as crops ripen according to type of crop planted

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section		Material		Treatment	Procedure	Frequency	Comments
					• Where historic accuracy is required scythes or sickles should be used • Dispose of crops in accordance with procedure planned for each site		
			f.	Clean up	• Inspect field areas during season and remove any paper, trash, etc., which accumulate; after harvesting, clean up any remaining trash, paper, etc.	C	• Minor clean up required only as necessary
STRUCTURES AND FURNISHINGS Note: "Structures" pertains to all constructed elements which are permanently in place in or on the ground; "Furnishings" are items which are movable or fixed but are secondary elements in a grounds development.	8.	Fences, gates	a.	Inspection, repair	• Replace all broken or damaged rails, pickets, boards, etc.; replace all rotted posts or other members • Ensure that fence members are horizontal and vertically aligned • All hardware, wire, nails or other fastenings to be firmly attached, free of broken or damaged pieces • Hinges and gates to be operating freely	B C	
	9.	Walls: seat, retaining, etc.	a.	Repair, cleaning	• Replace any broken, loose or damaged elements, loose or broken mortar; ensure that wall is stable and erect and horizontally and vertically aligned (use original materials)	C	

5.0 APPENDIX 3: METHODS OF MAINTENANCE
SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
			• Remove any surface vandalism by washing with suitable materials	B	• Repair and replace damaged or missing sections using original materials
10.	Edgings, curbs, copings	a. Repair, inspection	• Ensure that all edgings and curbs are intact with no broken or missing sections or misaligned sections		
			• For wooden edgings, ensure they are vertical and firmly held in place with no broken or rotten sections		
11.	Shelters, trelisses	a. Inspection, repair, cleaning	• Ensure that all footings, uprights and verticals are in place	B	• Make repairs as required using same materials and surface finishes
			• Ensure all paint or other surface finishes are intact		
			• Ensure all hardware is intact		
			• Roofs to be in good repair and free of leaks; floors solid and free of debris or trash		• Remove excessive snow accumulation on roofs
			• Sweep and wash floors in spring and as required during season		
12.	Pools, fountains, water containers	a. Inspection, repair, cleaning	• Inspect for cracks, broken or damaged areas	B	• Drain and refill pad as required for cleaning
			• Ensure all drains or inlets are clean and functioning and that no leakage exists from pool sides or bottoms		

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION B – GROUNDS

Element/Section	Material	Treatment	Procedure	Frequency	Comments
			• Remove all trash, debris, etc., from pool bottom or water surface		
			• Empty pools in fall and refill after cleaning each spring		
13.	Ornaments	a. Inspection, repair, cleaning	• Ensure footings are firm and level, ornament is firmly attached and erect, surface is free of cracks or other defects. Repair surfaces using restoration techniques	C	• Pertains to statuary, sundials or other ornaments used in garden areas
			• Clean by washing with mild detergents and rinse with clean water		
14.	Benches, signs, lights, etc.	a. Inspection, repair, cleaning	• Ensure that footings are firm and level and supports are firmly in place	B	• Repair and replace any damaged elements using the same materials as the original
			• All members free of cracks, splits, warping or other defects		
			• Surface finishes to be intact, free of splinters		
			• All hardware, fasteners to be firmly anchored with no missing elements and free of corrosion		
			• Wash in spring and as required (mild detergents)		

5.0 APPENDIX 3: METHODS OF MAINTENANCE

SECTION B – GROUNDS

Element/Section		Material	Treatment	Procedure	Frequency	Comments
SURFACED AREAS "Surfaced areas" pertains to walks, paths, terraces, driveways, sitting areas, yards, etc.	15.	Gravel, earth, cinders, bark	a. Repair, cleaning	• Level surface areas, fill all depressions, add additional material as required, rake material back to intended location and ensure that edgings are intact and limits of walks are defined	B	• Use care to maintain original character and size of areas
				• Roll and compact material to achieve smooth surface		
				• Ensure that drainage is positive and structures are clean and functioning		
				• Remove all trash, debris as it occurs	A–B	• Replace damaged or missing sections with same materials as originally used
	16.	Stone, brick, wood, etc.	a. Repair, cleaning	• Ensure that all surfaces are level, with no sunken or protruding elements, no broken, split, damaged or missing elements, all joints intact		
				• On wood surfaces, no loose, split, rotten or missing boards, all members firmly fastened to supports		
				• Clean surfaces with water to remove soil and foreign matter; sweep surfaces with broom weekly or as necessary to remove soil, sand or other material; pick up all paper trash, etc.		

5.0 APPENDIX 3: METHODS OF MAINTENANCE
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Element/Section	Material	Treatment	Procedure	Frequency	Comments
17.	Asphalt, concrete	a. Repair, cleaning	• Repair all damaged sections; fill all cracks and all depressions with asphalt or concrete • Sweep areas clean of sand and other material in spring and as necessary during season, rinse down with water several times per season • Ensure all areas are well drained • Pick up all debris, trash, etc.	C	• Not normally prevalent on period sites
		b. Snow removal	• Remove snow when accumulated to a depth of 50 mm; use hand shovels or small snow blowers • Use care not to damage surface areas by digging up gravel, earth, etc. or by damaging stone, brick or wood with removal equipment which can gouge or split materials • Do not chop ice from paved areas • Do not use salt for snow removal	A–B	• Remove snow only from areas which will be used during winter season
			• Where sand is used remove excess by sweeping and washing in spring after snow is gone		• Do not dispose of snow by stockpiling it on planted areas (flower or shrub beds)

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VOLUME V

CONSERVATION MAINTENANCE

2.2

MAINTENANCE PROCEDURES

MAINTENANCE INSPECTIONS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: B. JOHNSON

CONTENTS

1.0 INTRODUCTION

In accordance with Canadian Parks Service (previously Parks Canada) Policy Directives, inspections of all historic assets must be undertaken every year to provide information for work scheduling, annual budgeting and work quality control. This paper describes the methods and times of inspections.

1.1 TIMING

Inspections will be undertaken three times during the year:

a. in the early Spring (when ground thaws) to identify the location and nature of work which can be undertaken within the next few months, as part of the Maintenance Management Work Program;

Maintenance Inspections

b. in the late Autumn (after leaves fall) to identify the location and nature of work which:
   - can be undertaken within the next few months as part of the Maintenance Management Work Program
   - must be included in the next year's Maintenance Management Work Program after adjustments based on the actual budget; and

c. in the Summer or other suitable time to assess the quality of maintenance work, for the purpose of revising maintenance standards.

2.0 MMS MAINTENANCE STANDARDS

2.1 RESPONSIBLE PERSONS

Within the Maintenance Management System (MMS), function code 500 is for the inspection and preventive maintenance of buildings. This function should be undertaken by suitably qualified tradespeople. However, it is recommended that the Supervisor or General Works Manager, where appropriate, accompany the tradespeople and assist with the actual inspection report.

The inspection for maintenance quality should be undertaken by the General Works Manager, Regional Maintenance Coordinator and, where possible, a professional from the Region's Architectural and Engineering Service (A&ES).

General Works staff should also document defects while undertaking other activities and report the location, size and nature of any defects by the procedure established on their site.

2.2 METHOD

The annual and semi-annual inspection should be undertaken in systematic fashion. This requires the use of consistent descriptions, procedures and forms.

2.3 DESCRIPTION OF WORK REQUIRED

The deficiencies should be noted using a terminology which can be easily related to maintenance functions and methods. To do this it is best to make frequent reference to the quality standards of the MMS and identify the appropriate maintenance function and method. Only conditions not permitted in the quality standard need be noted.

3.0 RECORDING OF INFORMATION

The following list is presented as a suggested order for inspection notations. Previous inspections may be used as a guide.

3.1 GROUNDS

- non-turf areas
- turfed areas
- gardens
- pathways and trails
- fences
- outbuildings
- bridges (non-road)
- trees and shrubs

Transformer

3.2 BUILDINGS

a. Exterior
- north side – roof, wall, foundation, windows, doors
- east side – roof, wall, foundation, windows, doors
- south side – roof, wall, foundation, windows, doors
- west side – roof, wall, foundation, windows, doors
- porches and other add-ons

b. Interior
- top floor – each room (ceiling, walls, doors, windows),
  circulation spaces, service areas
- other floors – as above
- basement – as above

3.3 SERVICES

- Electrical
  – from the hydro transformer or meter to building fuse boxes
- Water supply
  – from the main valve (curb-stop) to faucets through hot-water tank
- Waste water
  – from the sewer connection to drains
- Fire protection
  – from the detectors to communication panels or alarms
  – from sprinklers to mains connection, where applicable
  – suppression equipment
- Lighting
  – from fuse boxes to bulbs
  – emergency backup, where applicable
- Electrical fixtures
- Telecommunications
- Heating
  – from fuel supply point to furnace (heat exchanger)
  – from heat exchanger to chimney top
  – from heat exchanger to diffusers
- Cooling
  – from heat exchanger to ducting (plenum)
  – from plenum to diffusers

4.0 FORMS AND EQUIPMENT

4.1 FORMS

The form presented in Appendix A is a model only.

If other forms are used they should contain:

a. the nature of work needed; a short (less than 20 character description) of the work with associated MMS function and method numbers;
b. identification of the location, using the asset number and identifying the location (room), etc., of the work;
c. priority of work, using a consistent scale
(e.g. '1' = must be done for public safety, '2' = needed to stop further deterioration of asset, '3' = needed to meet quality standard); and
d. area or amount of work, using the work units identified in the MMS function list.

This is essentially the same information recorded on the MMS work orders so that if desired, work orders could easily be used as inspection reports, in which case copy 2 of the work orders should be kept as the inspection report for future reference. By doing the inspections in this manner it is not necessary to maintain schedules of works, such as painting, etc.

Maintenance Equipment

4.2 EQUIPMENT

The annual inspection for scheduling the maintenance work should be done in conjunction with function 500 so that the following equipment will be available:

- appropriately sized ladders and, where necessary, safety lines
- equipment for probing (do not use round pointed awls, etc.) and lifting materials
- equipment for cleaning surfaces.

For the maintenance quality inspection and also for the work program inspections, the following equipment is desirable:

- binoculars or telescope (at least 7 x 24)
- moisture meter for wood
- sample bags
- Polaroid camera
- tape recorder (better than note pad).

Inspectors should be appropriately dressed for safety and warmth.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

5.0 APPENDIX: SAMPLE INSPECTION REPORT

DATE ____________________

FACILITY ____________________________ **ASSET** ____

INSPECTORS __________________ __________________ __________________ __________________

LOCATION	DEFECT DESCRIPTION	PRIORITY	FUNCTION #	WORK QUANTITY

VOLUME V
CONSERVATION MAINTENANCE

2.3
MAINTENANCE PROCEDURES
PERIODIC WORKS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

Periodic works are maintenance activities that occur cyclically. Some housekeeping may occur daily or seasonally, while other activities such as repainting or roofing will occur every so many years. This article is divided by building and site component.

1.1 PURPOSE

The purpose of maintenance for historic structures and sites is to prolong the life of the various elements of which they are made as well as to provide a clean and safe environment. It is impossible to stop deterioration, but quality maintenance will slow the process.

> **Maintenance**
> Conservation involves not just a once-in-a-lifetime intervention to a cultural resource but equally its routine and cyclical maintenance. The Canadian Parks Service will employ conservation maintenance to mitigate wear and deterioration without altering the performance, integrity or appearance of a resource.
>
> **Preservation**
> Preservation encompasses conservation activities that consolidate and maintain the existing form, material and integrity of a resource. Preservation includes short-term protective measures as well as long-term actions to retard deterioration or prevent damage. Preservation extends the life of the resource by providing it with a secure and stable environment.
>
> Preservation activities will involve the least possible physical intervention and, in the case of interim measures, be as reversible as possible, so as not to jeopardize long-term conservation options. In the case of long term measures, preservation activities ensure the stability and security of a resource so that it can be kept serviceable through routine maintenance. (Section 3.4.2 – .3, CRM)

Philosophically, maintenance of historic structures differs from maintenance of modern structures in that building materials are not considered sacrificial; instead, emphasis is placed on preserving, repairing and maintaining historic building fabric. The frequency of cycles for periodic works will vary depending on the building function, the amount of visitation, the nature of the building material, the climate and the detailing of the building.

In operating a historic site, interpretive programming may play a role in maintenance. For example, a slightly run-down appearance may be historically appropriate in which case extremely diligent monitoring of the building will be necessary.

1.2 RESEARCH AND DOCUMENTATION

Careful record keeping is an important part of maintenance. It is important to record observations from inspections and to record what work was undertaken, when and by whom. Original design drawings and specifications must be kept on hand and consulted. These provide valuable insights into the configuration and characteristics of materials. Also it is important that the design intent be recognized in the maintenance approach.

1.3 MATERIALS

Special care must be taken to avoid use of inappropriate materials. For example, latex paints will fail if applied over alkyd paints.

Where dissimilar materials meet, careful monitoring or intervention may be in order. For example, iron cresting fastened to a copper roof with no insulation between them will cause a galvanic reaction causing the deterioration of the iron.

1.4 SIGNIFICANT FEATURES

Cyclical maintenance of some features may fall under the jurisdiction of professional conservators (for example original wallpapers or decorative finishes on trim or plaster).

Robert Service Cabin, Dawson, YT

1.5 INSPECTIONS

Buildings and grounds should be thoroughly inspected at least once a year. Carefully worded notes and photographs should be used in conjunction with a checklist so that conditions can be monitored from year-to-year.

2.0 BUILDING EXTERIOR

2.1 ROOFS

For the purpose of this discussion roofs are considered to consist of a roof covering, e.g. cedar shingles and usually both flashings and a rainwater disposal system.

2.1.1 Inspections

Roofs should be examined in the spring and fall. Damaged fabric and obstructions which could impede the flow of water must be noted. Other features such as chimneys, vents, parapet walls or cresting should also be examined at these times. Flashings between the roof covering and dissimilar materials are susceptible to damage and must also be examined closely.

Inspections should also be undertaken after bad storms or other unusual occurrences. Moisture in attics or ceilings is frequently caused by failure of roofing materials although condensation or plumbing faults may cause similar symptoms.

2.1.2 Cléaning

Eavestroughs, valleys, roof drains or any other areas where debris may collect should be cleaned at least every fall or more frequently if local conditions, such as a forest environment, dictate.

Roof Covering Replacement

2.1.3 Repair and Replacement

Roof coverings may be damaged as a result of abrasion, wind, corrosion, fatigue or decay. Individual units of unit roofing materials are tricky to repair but many techniques exist. See Vol. IV.4.

There is a wide range in lifespans for roofing materials; lifespan is affected by the nature and quality of the material, exposure to weather and pollutants, roof pitch, building detailing, etc. An approximate range in lifespans for some roofing materials is given below:

Wood shingles or shakes	15-60 years
Boards	2-5 years
Metal	35-100 years
Asphalt	10-20 years
Bituminous membrane or tar and gravel	15-20 years
Thatch	40-75 years
Slate	70-100 years

Flashings protect joints where different roof pitches meet and between the roofing material and dissimilar materials. They are replaced when the roof covering is replaced.

2.1.4 Special Consideration

a. Paint:
Some roofing materials such as cedar shingles were painted historically. Because of exposure, paint may require reapplication every five years.

b. Fungicides:
Some wooden roofing materials used in damp or shaded locations may require the application of preservatives to extend their lifespan. Preservatives can retard fungal and insect-caused decay and the growth of mosses or lichens. Reapplication may be necessary every two to four years.

c. Heating Cables:
Heating cables are sometimes used to prevent the formation of ice on building eaves or in downspouts. The condition of the cables and their attachment to the building fabric should be checked in the spring and fall. The cables must be turned on at the start of winter and off in the spring.

2.2 WALLS OR VERTICAL SURFACES

Many materials in different configurations are used to construct exterior walls or vertical surfaces. Masonry walls usually consist of either clay, brick or stone; wood walls are either framed or log, but either may be covered in metal, shingles, clapboard or board and batten. Some exterior surfaces are rendered with a clay or cementitous parging. Poured concrete is frequently used for foundation walls or walls of industrial buildings or military fortifications.

Periodic work required for these different materials and different configurations will vary greatly depending on the nature and quality of the material, exposure to weather and pollutants and the detailing of the building.

2.2.1 Inspections

Exterior wall surfaces should be carefully examined each spring so that any necessary repair work can be undertaken during that building season.

Dirt and grime should be swept and wiped from painted wood and metal surfaces as it accumulates.

Complete repainting of the building envelope is only required every ten years if proper surface preparation is done. Localized areas which suffer from abrasion may be touched up each building season. Constant paint failure in certain areas should be addressed by a building conservator. Every 30 to 40 years it may be necessary to remove paint in protected areas to avoid excessive buildup of paint.

2.2.2 Unpainted Wood

Unpainted wood such as siding or log work will require regular attention. Areas which show signs of fungal attack should be treated with fungicide every one to three years. Areas which show signs of insect attack should be treated annually with insecticide. Wooden surfaces which tend to collect moisture, such as window sills, should be treated with water repellent, or a water repellent with a preservative every two to four years. Exposed unpainted siding and exposed log work may eventually require replacement. Sections of exposed wood siding may require replacement every 40 to 70 years.

The life expectancy of log work may be greatly extended by splicing into and filling open checks or decayed areas. Logs which require most frequent replacement are sills. If untreated with preservatives, cedar or tamarack sills in close contact with the ground will lose their structural integrity within 50 to 80 years and will require replacement.

2.2.3 Cleaning – Masonry and Concrete

Masonry, either brick or stone, may require cleaning to remove graffiti, efflorescence or surface crusts resulting from atmospheric pollution or soiling.

Some types of crusts or soiling may be washed from the building with low pressure water. Efflorescence may be removed by poulticing. Some soiling does no harm and need not be removed. There are so many variables and conservation issues involved in cleaning masonry that no attempt to define a frequency shall be made here.

For information on cleaning, see Vol. IV.4.

2.2.4 Pointing – Masonry

Good quality mortar, if protected from the elements, may last for centuries. Masonry exposed to moisture, freeze/thaw cycles and/or a saline environment usually requires repointing every 10 to 20 years. On the average, an exterior masonry wall will require total repointing every 40 to 60 years. Patch pointing deteriorated areas every five years may make total repointing unnecessary.

For information on repointing, see Vol. IV.4.1.3

Quebec City, PQ

2.2.5 Replacement and Repair – Masonry and Concrete

Damaged masonry units or concrete elements may require repair or replacement because of deterioration due to abrasion, freeze/thaw cycles, exposure to salt or atmospheric pollution or improper repair techiques. There are so many variables and conservation issues involved in cleaning masonry, that no attempt shall be made here to define the frequency of replacement and repair.

For information on masonry stabilization, see Vol. IV.

2.2.6 Renderings

Renderings of lime and sand, cement and aggregate or clay, sand and straw may be found covering frame, log or masonry buildings.

Because of their rough texture, renderings are difficult to clean. Soiled or dusty sections may be swept with a brush or broom a few times a year for aesthetic reasons. A low-pressure water spray and gentle brushing may be appropriate for cementitous renderings every few years.

Contact with moisture and resultant damage may necessitate cutting out and patching lime, cement or sand renderings near grade every 5 to 20 years.

Deteriorated Concrete

Clay, sand or straw renderings may require repair every year if there is direct contact with moisture. For example, Ukrainians who settled western Canada traditionally repaired the mud plaster on their log houses and whitewashed it every spring in preparation for Easter celebrations. At some historic sites this is a part of the interpretive program.

In log buildings, daubing between the logs will require repair in exposed areas every two to five years. Complete replacement may be required every twenty years.

For more information on chinking, see Vol. IV.2.2.2.

2.3 WINDOWS

For the purpose of this discussion windows are considered to consist of sashes, frames, trim and hardware.

Windows should be thoroughly inspected and cleaned in the spring and fall, ideally when the storm windows are being removed or installed. Inspections should also occur during weekly dusting or immediately after storms have occurred.

If there are storm windows which must be installed in the fall and removed in the spring, cleaning should occur at this time. Dusting of the window interior should be done weekly.

Exterior surfaces of windows will require painting every ten years. In protected areas paint may have to be removed every 30 to 40 years to avoid excessive paint buildup.

2.3.1 Repair

Because of its brittle, fragile nature, glass is sometimes broken through accident or vandalism. It requires immediate repair to avoid moisture infiltration and heat loss.

In exposed areas glazing putty may require replacement every 20 to 40 years. If maintenance is neglected or windows are left unpainted, bottom rails of window sashes and window sills may require repair or replacement every 40 to 75 years.

In double-hung windows sash cords may require adjusting every five years and replacement every 40 to 50 years.

For information on Window Repair, see Vol. IV.4.4.

2.4 DOORS

For the purpose of this discussion doors are considered to consist of doors, frames, trim, sill and hardware.

Doors should be closely examined once a year. The part most likely to wear is the hardware - hinges, latches and locks.

Doors should be dusted once a week and it may be necessary to wash grime from frequently used doors at the same time. Every ten years it may be necessary to remove hardware for extensive cleaning.

2.4.1 Painting and Repair

Exterior doors should not require painting more than once every ten years. Frequently used doors may require touching up annually because of abrasion. Paint removal may be necessary every ten years to ensure free-floating panels can move and that the door continues to fit the frame properly.

Halifax Citadel

Frequently used doors may require repairs to hardware every two to three years; for example, springs in locks may break or set screws in door knobs may work loose. Door sills will require frequent replacement if constructed of softwood but less frequent replacement if constructed of hardwood. Locks and hinges require oiling seasonally.

2.4.2 Storm and Screen Doors

Storm and screen doors will require changing seasonally.

For information on "Stabilization: Windows and Doors" and "Stabilization: Hardware," see Vol. IV.4.

3.0 BUILDING INTERIOR

3.1 ATTICS AND CRAWL SPACES

Attics and crawl spaces should each be inspected twice a year and cleaned annually.

3.2 FOUNDATIONS

Each spring, after the snow has melted and the frost has left the ground, foundations should be carefully examined for defects.

Cyclical masonry repairs described in 2.2 above "Walls or Vertical Surfaces" apply. Concrete foundations may require repair, e.g. grouting or patching if settlement cracks appear.

Mud sills or other foundations bearing directly on grade may require levelling each spring.

Foundations on permafrost may have jacks or wedges at each crib or point of bearing which will require adjustment and levelling every spring.

3.3 WALLS AND CEILINGS

Most finished walls and ceilings consist of fabric, paper or paint over plaster with applied wood or plaster trim or decorations.

As part of the annual inspection walls and ceilings should be carefully examined.

Light dusting, concentrating on horizontal ledges and wiping of frequently handled switches, will be required biweekly. Thorough cleaning of walls and ceilings is required annually.

Interior trim, walls and ceilings will require repainting every 10 to 20 years.

3.4 FLOORS

Materials used for floors include masonry, mud, logs when flat on top, painted and untreated softwood boards or hardwood boards with a clear finish and possibly a stain, linoleum and floor cloths.

Floors should be examined as part of the annual building inspection.

Mats and runners are frequently used to both limit the extent to which soil is tracked into a building and to control abrasion. In high traffic areas mats or runners should be vacuumed or shaken out daily. The floor beneath should be cleaned at the same time. In high traffic areas floors may be swept or vacuumed twice a week. Depending on the weather and the traffic, floors should be washed as required. As a wax finish or painted finish starts to wear it should be touched up. Repainting or rewaxing the entire floor should be avoided. An excessive buildup of paint or wax may have to be removed from time to time.

3.5 MECHANICAL SYSTEMS

3.5.1 Heating Systems

Any heating system should be examined by a trained professional before the start of each heating season. In hot water or steam systems, boilers and burners will require replacement every 15 to 25 years. Safety valves, thermometers and flue connections should be checked regularly. Radiators and, where possible, pipes, should be checked for leaks and corrosion. In forced-air systems filters should be changed monthly during the heating season. If in regular use, stoves and fireplaces must be cleaned. Stovepipes should be cleaned, preferably outdoors, twice a year. Masonry flues should be cleaned and carefully inspected once a year.

3.5.2 Electrical Systems

The electrical system should be examined annually. An electrician should be consulted if circuits overload and fuses are blown regularly.

3.5.3 Security Systems

Security systems should be thoroughly tested annually and updated if required. If possible any security system should be tested daily.

3.5.4 Plumbing Systems

Pumps for wells and cisterns should be checked annually. Cisterns should be cleaned every two years. Depending on use and soil conditions septic tanks may have to be pumped out annually. Depending on minerals in the water, toilet tanks may require periodic cleaning. Hot water tanks should be drained and rinsed once a year. Washers and items liable to wear in taps and fixtures need to be replaced as required. Sump pumps should be equipped with a high water warning alarm. This should be checked regularly in damp seasons.

4.0 GROUNDS

4.1 GENERAL

The types of periodic works (and the frequency with which they are performed) required to maintain grounds will vary with the types of plantings and constructed elements and furnishings. Soil types, climate, seasonal changes, usage and the amount of traffic will also have to be considered.

4.2 FOUNDATION PLANTINGS

Foundation plantings require a special level of maintenance because of the danger they can pose to building fabric. Each spring limbs and branches which could abrade the building or prevent the actions of sun and wind from drying the building, must be cut back.

Most of the following information is taken from Section 2.1 "Maintenance Procedures: Housekeeping Programs."

4.3 LAWNS AND GRASSED AREAS

> These are treated with respect to the species of grass grown, historic and contemporary function, frequency and type of use, location and seasonal and climatic conditions. Some areas are highly maintained for appearance, such as in display gardens, while others are maintained to a lesser degree such as meadows or fields around fortifications which should resemble historic conditions. Use extreme care in maintaining healthy growing conditions through careful and timely maintenance practices.

Victorian Bathroom

Maintenance practices include mowing, trimming, watering, fertilizing, aerating and weeding. Annual reseeding or sodding of some areas may be required. In the spring and fall, leaves, dried grass and debris should be raked up and removed. Paper and other trash should be removed as regularly as possible.

4.4 TREES AND SHRUBS

Treatment of trees and shrubs depends on the species involved, their growth habits, climatic conditions, their use or purpose in a given grounds development and their location within the historic site. Where they form a part of the natural historic setting there is little or no maintenance involved as they are allowed to grow to natural maturity. However, where they have been planted as specimens to form a part of a garden setting, as woodbreaks or hedges or in orchards, maintenance practices will be governed by and according to the specific site requirements.

Under the circumstances regular maintenance may include pruning, watering, mulching, fertilizing and possibly spraying to control insects.

4.5 PLANTING BEDS

The treatment of shrubs, annuals and perennials planted in organized planting areas which are clearly delineated, varies with the species and types of plants, climatic conditions, seasonal changes and intended purpose of a particular planted area.

Very formalized plantings require more frequent and precise maintenance. Annual planting beds require yearly seasonal plant replacement and careful planting with the same species, whereas perennial plantings need only seasonal care with occasional replanting of dead or damaged plant materials.

4.6 GROUND COVERS

Areas planted in ground covers require a minimum of care other than occasional trimming or cutting back of growth or replacement of dead or diseased material. Maintenance practices will vary according to species involved, location and purpose of the planting and climatic and seasonal conditions.

4.7 VEGETABLE GARDENS AND CROPPED AREAS

These areas require frequent attention during the growing season, again depending on the type of plants or crops involved, the climatic conditions and their role within a particular site. Garden or cropped areas in historic sites are usually developed to reestablish areas to historic use patterns and are therefore maintained either as areas for interpretation using methods and materials based on historic practices or using contemporary or mixed maintenance practices where interpretation is not a key factor.

4.8 CONSTRUCTED ELEMENTS AND FURNISHINGS

Examples of constructed elements in the landscaped areas of sites are fences, walls, shelters and pools. Furnishings include statues, swings, benches, seats, flagpoles and lights. These require varying degrees of maintenance depending on the type of element, the materials used and their exposure to varying use and climatic conditions. Among the procedures necessary are regular cleaning, stabilization and minor repairs to ensure safety.

4.9 SURFACED AREAS

These are ground areas other than grassed or planted areas which have been stabilized in some form primarily for circulation or as rest or other public use areas. Included are walks, drives, paths, patios, yards, copings, edgings, parade grounds, embankments and other areas covered with stabilized earth, stone, gravel, boards, etc., providing a firm footing or to contain an area in an overall grounds development. Normally maintenance requirements are minimal and consist of keeping areas clean and well drained, making minor periodic repairs and stabilizing or replacing eroded materials.

Hard-surfaced paths leading to or from a building should be swept regularly to avoid tracking loose material into the building interior. During winter months it will be necessary to remove ice and snow.

Bench in Britannia, near Ottawa, ON

5.0 BIBLIOGRAPHY

Alberta Culture. 1986. "Rutherford House, Maintenance Specifications." December. "Pylypon House Interim Janitorial Specifications." Unpublished. Historic Sites Services, Construction and Maintenance Program. Both of these documents contain valuable housekeeping information for historic structures, including recommended products and cleaning techniques.

Chambers, J. Henry. 1976. *Cyclical Maintenance for Historic Buildings*. Interagency Historic Architectural Services Program. Office of Archaeology and Historic Preservation, National Park Service, U.S. Department of the Interior, Washington, DC.
This book is still the best reference on housekeeping for historic structures.

VOLUME V
CONSERVATION MAINTENANCE

3
EMERGENCY WORKS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
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OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT LIMITED

CONTENTS

1.0 INTRODUCTION

This volume on Conservation Maintenance provides guidance in the continuing conservation of historic structures. It is complementary to DRM 10-7/90 "Maintenance and Operation of Building Facilities." Together, these two manuals form part of the Departmental Maintenance Management System.

This article is intended to assist staff on historic sites who are responsible for operating and maintaining historic buildings, structures and sites, including standard procedures to be followed in an emergency.

2.0 EMERGENCY PROCEDURES

Emergency works are necessary whenever historic structures are damaged unexpectedly by fire, flooding, winds or other natural or human causes.

Structures affected by unexpected damage must be immediately secured and stabilized to prevent further damage. This is done in several stages described below in terms of personnel involvement (see 3.0).

3.0 PERSONNEL

3.1 IMMEDIATE ACTION

When they observe an emergency, personnel on the site shall immediately notify the site superintendent or officer in charge. The officer in charge shall:

a. secure the safety of people on the site;
b. secure the structure as much as safety and capability allow. Structural integrity and weather-proofing are the usual priorities. The officer should take care that inappropriate temporary protective measures do not further damage the structure or its contents;
c. notify specialists immediately, where historic resources, including artifacts, have been damaged. For such purpose a list of telephone numbers and addresses should be kept on site;
d. notify the appropriate regional office;
e. implement directives from the regional office;
f. prepare conditions for specialists coming to deal with the emergency work; and
g. in case of fire damage exceeding $1,000, contact the Fire Commissioner of Canada or the regional office. Proper procedures for reporting are described in Program Reference Manual, part 3, section 1.11 and the current Fire Commission of Canada Standard 11, "Investigation and Reporting of Fire."

The work described above may take from several hours to several days.

3.2 SPECIALIST ACTIONS

After the officer in charge has directed completion of the above work, specialists normally are called in to analyse the damage and make recommendations for the preservation of the site or structure and the prevention of such an emergency recurring.

Specialists involved at this stage of work may be site staff, regional officers, headquarters officers or consultants.

The regional office will inform the site superintendent on what activity is proposed, how long it will take, when it has been completed and which officers are concerned.

Following investigation, the structure or structures shall be secured against further deterioration, while providing access for investigation and maintenance.

The superintendent shall request instructions and authorization for this work from the regional office.

3.3 PLANNING MINOR AND MAJOR WORKS

Minor works are considered part of site maintenance activity and are paid for from operational funds. These works should be designed and executed within the context of the maintenance specifications for the site.

Major repair works, not paid for out of operational funds, require a project authorization and commitment of capital funds. These works must follow the normal design process for stabilization or restoration of historic structures. The goal is to retain as much as possible of the original fabric and to return the structure to its normal function and standard of maintenance.

Damaged Site, Dawson, YT

4.0 ASSESSMENT OF COMPLETED PRESERVATION WORK

After the preservation work is completed, a project assessment shall be prepared. It shall be in the form of a report and shall cover the whole action as follows:

a. identification of the site or structure;
b. description of the emergency situation;
c. a report of the activities or personnel and institutions dealing with the emergency situation;
d. evaluation of the causes of the emergency;
e. evaluation of immediate and long-term measures applied;
f. evaluation of the emergency work program as implemented;
g. recommendations for continuing maintenance; and
h. recommendations for prevention of recurrence.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME V

CONSERVATION MAINTENANCE

4

MONITORING PROGRAMS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
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ORIGINAL DRAFT: S. HUM-HARTLEY

CONTENTS

1.0 INTRODUCTION

This article outlines the criteria that must be considered for the systematic planning and implementation of a monitoring program. The extensive bibliography serves as a source of detailed information on specific methods, experimental techniques and equipment referenced within this article.

Micro Level Recorder
Sperry Anglestar™
Courtesy of EMACO (Canada) Ltd., Montreal, PQ

1.1 DEFINITION

Monitoring is the task of collecting and recording data in a systematic and repetitive manner for the purpose of correlating and comparing the physical performance and condition of the quantity being examined to related quantities. Unlike inspection, monitoring has an identified objective and is clearly defined in terms of what is to be measured, when and how this is to be accomplished for how long and who is responsible for the execution of the program and for interpreting and using the results.

Monitoring is one on-site method of assessing changing structural, material, geotechnical and environmental conditions which affect the conservation and maintenance of historic structures and sites. The results obtained contribute to the evaluation of restoration and maintenance techniques and the assessment of problems and suspected changes of condition.

Regular and repetitive maintenance functions such as seasonal inspections are not considered monitoring programs (see Section .2.3 "Maintenance Procedures: Periodic Works"). However, the need to establish a monitoring program could be identified during regular cyclic inspections.

1.2 SCOPE

Monitoring may be an independent maintenance or project activity, form part of a wider investigation and analysis program or be incorporated into the regular maintenance activities of the site. Correspondingly, it can be contracted out to a consultant or carried out entirely by the area superintendent and staff; the arrangement depends on the scope and complexity of the work to be accomplished and the skills and availability of the required resources.

2.0 ESTABLISHING A MONITORING PROGRAM

2.1 OBJECTIVES

For those directly involved in projects related to site development a monitoring program could be identified to:

a. assess the possible presence and causes of deterioration and instability;
b. understand situational behaviour of structural form and material characteristics; and
c. assess the effect of changes to the original loading, member configuration or environment and the use of new technology on the performance behaviour of the structure. These post-development assessment requirements would generally be identified by the design team in the maintenance manual developed for the site.

For those concerned with the continuing on-site maintenance and operation of the site, such a program could provide:

a. assessment of deterioration and instability problems identified during the routine maintenance work; and
b. assessment of the effects of conservation and maintenance procedures on the overall performance and appearance.

2.2 IMPLEMENTATION

The routine for implementation varies with the scope of work. In general, project managers and area superintendents can best recognize the need to initiate these types of programs. The reports, recommendations and requests they receive from their staff will form the basis for judging the program's importance, scope and objectives.

3.0 PLANNING A MONITORING PROGRAM

3.1 GENERAL CONSIDERATIONS

A monitoring operation is a chain of potential weak links. The need for reliable techniques is only one consideration. Careful planning is essential and should encompass such aspects as definition of objectives and quantities to be measured and decisions on the type, number, location and frequency of measurements and on the organization of personnel, equipment, measurements and reporting procedures. Only if each of these aspects is considered in detail before the start of the project will there be any certainty of accomplishing the objectives.

3.2 TERMS OF REFERENCE

Regardless of the program complexity and whether or not the work is to be done by site personnel, regional staff or outside consultants, the following steps should be taken:

a. Define clearly the monitoring objectives, including relationships to other project work and the anticipated use of results. This provides a guide for the appropriate level of resource expenditure and requirements for precision.
b. Define "normal" and "acceptable" behaviour and assess anticipated behavior.
c. If safety considerations exist, establish emergency contingency plans (see Section 3 "Emergency Works").
d. Determine which behavioural or material properties and characteristics are to be examined in order to achieve objectives. This requires isolating prime phenomena and identifying all factors which would influence results and which might require simultaneous measurement and establishing viable range and precision requirements.
e. Identify locations to be examined and, if required, establish a priority list of critical areas to be monitored. Often it is sufficient to provide an extensive area of low precision and low frequency of measurement, with a provision for more accurate, concentrated and frequent monitoring whenever the results indicate a change.
f. Estimate the duration of the project and frequency of measurements. Although a minimum number of readings should be predetermined, it is important to be able to match reading frequency to progress rather than to time elapsed.
g. Ensure that personnel with appropriate levels of experience and familiarity with the method and equipment employed are directly responsible for interpreting results and making recommendations.

Monitoring Riel House

3.3 MONITORING PROGRAM CONSIDERATIONS

3.3.1 Personnel

Depending on the requirements of the program, maintenance staff, professional and technical personnel or consultants might form an on-site monitoring team. One individual representing the team should co-ordinate the monitoring. Establishing liaison channels in advance ensures continuity and communication gathering, between those requiring the information and those performing the work. Unless specifically indicated in the terms of reference, the team is usually responsible for the

readings but not for interpretation or action that may be required by the results. This aspect of the work is not considered part of the monitoring, which is essentially a data-gathering exercise.

3.3.2 Equipment and Methods of Measurement

For each parameter to be measured, there are usually several methods and types of equipment that might be suitable. All have advantages and limitations. The following factors will influence the final selection:

a. Reliability
   The success of the program relies on the repeatability of the measurements. In general, selection of methods and equipment which are more sophisticated than necessary should be avoided. For every instrument selected there should be calibration methods and equipment to ensure that the instrument continues to function correctly throughout the duration of the project. Calibration helps ensure that the interpretation of the data is appropriate for the material and conditions being examined. This can be obtained from a variety of sources, including available calibration charts from equipment manufacturers, established procedures and technical literature and experimenting with the instrument to evaluate its performance relative to a known set of conditions.

b. Precision
   Requirements for precision usually reflect the objectives of the program. The more stringent the requirement, the more sophisticated, costly and time-consuming the monitoring project becomes. If, for example, a comparative visual observation will provide the information necessary to arrive at a decision, then more sophisticated methods of recording the data are redundant. A clear understanding of the precision requirements is necessary to satisfy program objectives.

c. Ease of use
d. Cost
e. Durability
f. Ease of repeatability of technique or method on-site
g. Personnel requirements
   This applies to the expertise required to use the equipment and to record and interpret the results.

Depth Meter
Courtesy of James Instruments, Chicago, IL

3.3.3 Measurement Plans

General guidelines for personnel, time requirements and frequency of each measurement should be established at the initial stage. It is advisable to assess the data on an ongoing basis in order to adjust the frequency of readings and to evaluate the validity of the recorded results. One should always establish routines for calibration checks of the equipment.

3.3.4 Processing Results

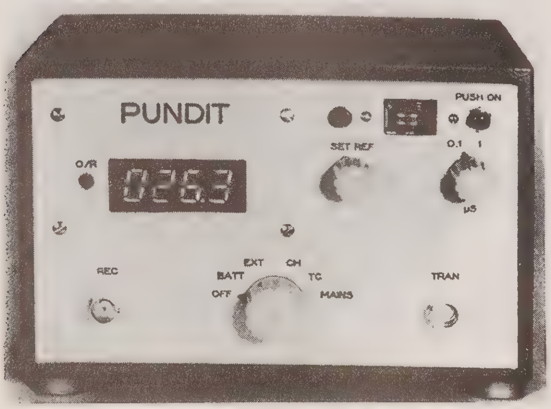
It is here that errors, delays and ambiguities can often occur. To avoid these:

a. process data as it becomes available. This provides a constant picture of the changing nature of the problem;

b. allocate responsibilities for calculation and plotting before the project starts; and
c. prepare results carefully, thereby assisting in interpretation of the behaviour under examination.

3.3.5 Reporting

Monitoring results forms a basis for action or for informed inaction. The report itself should establish a reference for the interpretation of the results (if not included as part of the terms of reference for the program) and include details on the equipment used, numbering systems employed, instrumentation performance, tests, calibration methods, data processing techniques and pertinent comments and observations which may have a bearing on the interpretation.



Pundit Ultrasound
CNS Instruments Ltd., London, UK
Courtesy of J.G. Lab. Material Inc., St-Laurent, PQ

4.0 MONITORING TECHNIQUES

(See Vol. III.10 "Special Investigation and Analysis" and the bibliography attached to this publication.)

Unlike dimension and weight, many parameters cannot be measured directly without altering or destroying the material or structural form. Fortunately, methods have been developed which provide an indirect means of assessment. These depend on the interrelationship among certain physical and mechanical properties of the materials of configuration being examined such as hardness, resistance to penetration and ability to transmit ultrasonic pulses and X-rays.

Once a specific program objective is determined, there is often more than one method of gathering the required data. The selection of the most appropriate technique should be based on the criteria outlined in 3.3.2 above.

The Appendix groups some of the commonly used methods according to the quantity to be measured. The lists are not meant to be exclusive, but to illustrate potential solutions. Details of each technique are not provided, although the general comments are extended to provide guidance.

More information can be found in the bibliography references listed and by contacting the resource organizations listed in 5.0 below.

5.0 SOURCE LIST

a. Associations/Organizations

Association of Consulting Engineers
of Canada
130 Albert Street
Ottawa, ON K1P 5G4 (613) 236-0569

Canadian Testing Association
Box 9175, Sta. T
Ottawa, ON K1G 3T9 (613) 744-3937

American Society for Testing
and Materials
1916 Race St.
Philadelphia, PA 19103

Forintek Canada Corp.:

Eastern Laboratory
800 Montreal Road
Ottawa, ON K1G 3Z5
(613) 744-0963

Western Laboratory
2665 East Mall
Vancouver, BC V6T 1W5
(604) 224-3221

b. Equipment: Suppliers and Manufacturers

At present in Canada the main sources for information on equipment and suppliers can be obtained from various directories such as “Frasers Construction and Building Directory” and the “Canadian Trade Index.”

Typical classifications for appropriate material are:

- detectors
- gauges
- instruments
- testers
- test equipment
- testing service.

The companies that supply and manufacture this type of equipment and instrumentation provide excellent assistance for selecting the appropriate technique and equipment needed.

6.0 APPENDIX: MONITORING TECHNIQUES AND APPLICATION

QUANTITY TO BE MEASURED	TECHNIQUE/INSTRUMENT AVAILABLE	APPLICATION			GENERAL COMMENTS
		W	M	O	
CRACK Movement and propagation	Hand recording and dating crack termination and width using sketches, photographs, etc., or on surface itself	x	x	x	Simple, inexpensive
	Breakable telltales (e.g. glass) attached to span across crack width	x	x	x	Simple, inexpensive; qualitative indication of crack activity
	Scratch gauges attached to span across crack width	x	x	x	Requires fairly plane surface for attachment; must protect from hostile environment; relatively expensive; provides record of movement
	Measurement between reference points using calipers, scales, Demec gauges, etc.	x	x	x	Simple, direct, inexpensive
DECAY	Observation	x	x	x	Locates surface decay only
	Probing	x	x	x	
also see DENSITY, MOISTURE CONTENT	Sampling and specimen analysis	x	x	x	Simple, inexpensive; repair such holes to prevent further deterioration
	Pulsed current resistance measurement using Shigometer	x			Detects patterns of electrical resistance that are associated with changes in wood tissue; only good above fibre saturation point (approximately 27 percent); developed for groundline detection of decay in utility poles; pattern, not value, of readings, indicate decay

** W – wood, M – masonry, O – other such as soil, metal, etc.

6.0 APPENDIX:
MONITORING TECHNIQUES AND APPLICATION

QUANTITY TO BE MEASURED	TECHNIQUE/INSTRUMENT AVAILABLE	APPLICATION			GENERAL COMMENTS
		W	M	O	
DENSITY	Hammer sounding	x	?	x	Simple, qualitative method of detecting relative density changes
	Radiography: using X-ray tubes or radioisotope cameras as a source and sensitized film	x	?	x	Technique based on recording on film the modification of penetrating radiation by the thickness and density of the specimen; expensive; handling of radioactive equipment requires special license; interpretation of radiographs requires experience
	Ultrasound: using portable indicating test equipment such as Pundit	x	x	x	Technique based on modification of ultrasonic pulse velocities by density and thickness of specimen; must be calibrated to type of material being examined
	Impact tests such as needle penetration tests	x	x	x	Calibrated to relate energy absorption properties of material to toughness, density and strength
DIMENSION	Hand measurement between established reference points using tapes, rules survey equipment, etc.	x	x	x	Simple, inexpensive, direct
	Measurement of strain changes using strain gauges and data acquisition instrumentation	x	x	x	Requires attachment of gauge to material; detects minute changes of dimension
	Ultrasonic testing	x	x	x	Can be calibrated to give dimensional measurements (thickness)

** W – wood, M – masonry, O – other such as soil, metal, etc.
? – currently experimental only

6.0 APPENDIX:
MONITORING TECHNIQUES AND APPLICATION

QUANTITY TO BE MEASURED	TECHNIQUE/INSTRUMENT AVAILABLE	APPLICATION			GENERAL COMMENTS
		W	M	O	
FUNGAL GROWTH	Aseptic field sampling and lab culture analysis	x	x	x	
HUMIDITY	Humidity gauges, sling hygrometers, wet/dry bulbs, etc.			x	Many commercially available instruments for the measurement and recording of humidity
LOADS					
Static	Strain gauges, forces gauges, cells	x	x	x	Require direct bonding to material; careful installation; specialized data acquisition equipment to take readings; expensive; expertise to install equipment and interpret results
Dynamic	– ditto –	x	x	x	
Vibration	Accelerometers	x	x	x	
Temperature	Thermometers, thermocouples			x	
Pressure					
• general	Pressure transducers			x	
• pore water	Piezometer			x	
• earth	Earth pressure cells			x	
MOISTURE CONTENT	Dry weighing of samples	x	x	x	Simple, inexpensive; gives absolute moisture content
also see, HUMIDITY	Electrical resistivity measurements using moisture meters	x	x	x	Simple, direct; calibrated to type of material
	Neutron modification using nuclear gauges	x	x		Thickness and density limitations for wood applications

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6.0 APPENDIX:
MONITORING TECHNIQUES AND APPLICATION

QUANTITY TO BE MEASURED	TECHNIQUE/INSTRUMENT AVAILABLE	APPLICATION			GENERAL COMMENTS
		W	M	O	
MOVEMENT CRACK Movement and propagation					
Ground surface movements:					
• settlement	Optical levelling on reference points			x	Simple, inexpensive, excellent reliability; benchmark required; care required to prevent pin disturbance
	Settlement gauges			x	Expensive, require datum for absolute movement
• lateral	Offsets from line defined by theodolite; tape measurements between survey points			x	Simple, inexpensive; requires fixed reference stations
	Extensometers			x	Expensive, susceptible to damage; requires fixed reference
	Inclinometer installed in ground			x	Gives full depth profile of lateral movement; take care not to disturb conditions during installation
Movement of Walls					
• vertical	Optical levelling onto points	x	x	x	Simple, inexpensive; necessary to have fixed benchmark
	Stereo-photogrammetry	x	x	x	Provides permanent photograph of wall section for future reference; requires optical levelling to establish absolute datum; necessary to establish target points on wall

** W – wood, M – masonry, O – other such as soil, metal, etc.

6.0 APPENDIX:
MONITORING TECHNIQUES AND APPLICATION

QUANTITY TO BE MEASURED	TECHNIQUE/INSTRUMENT AVAILABLE	APPLICATION			GENERAL COMMENTS
		W	M	O	
• lateral	Line of sight and offsets to reference pins	x	x	x	Requires datum for absolute movement; inexpensive, simple
	Suspended plumb line to give lateral displacement with depth	x	x	x	May be difficult to take offset measurements and keep line motionless; inexpensive
	Inclinometer tubes mounted on wall face	x	x	x	Requires special equipment to take readings; must be protected from disturbance
	Stereo-photogrammetry	x	x	x	Accuracy less for out-of-plane measurements
Deformation of structural elements, e.g. beams, columns					
• longitudinal	Strain gauges	x	x	x	Requires bonding to material; requires data acquisition instrumentation
	Scratch gauges	x	x	x	Provides history of movement without sophisticated recording equipment; special readout requirements; expensive
	Measurement between established reference points	x	x	x	Simple, inexpensive; limited to accuracy of scale
• lateral	Strain gauges	x	x	x	As per above
	Offset measurements to datum using dial gauges, etc.	x	x	x	Simple, direct, inexpensive

** W – wood, M – masonry, O – other such as soil, metal, etc.

6.0 APPENDIX:
MONITORING TECHNIQUES AND APPLICATION

QUANTITY TO BE MEASURED	TECHNIQUE/INSTRUMENT AVAILABLE	APPLICATION			GENERAL COMMENTS
		W	M	O	
TEMPERATURE	Thermometers and temperature recording devices			x	Many commercially available instruments for the measurement and recording of temperature
VOID DETECTION See **DENSITY**					

** W – wood, M – masonry, O – other such as soil, metal, etc.

7.0 BIBLIOGRAPHY

Material is listed under the following general subject headings:

- Decay
- Environment
- General Works
- Instrumentation
- Load Tests
- Moisture
- Movements
- Non-Destructive Testing
- Photogrammetry
- Radiography
- Survey Techniques
- Ultrasound

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